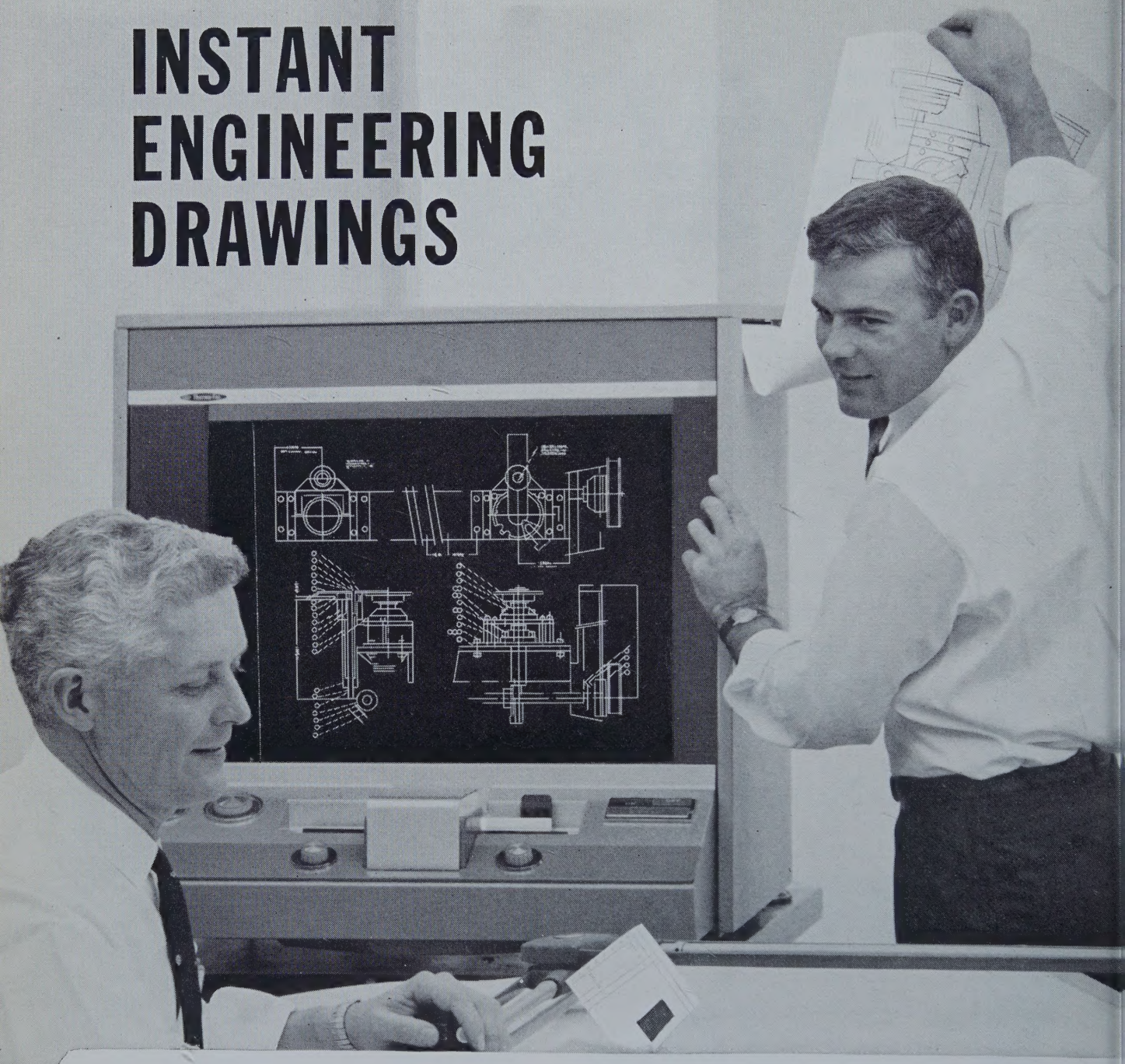
GRAPHIC SCIENCE

A New Look at Lists of Material

JULY, 1961

INSTANT ENGINEERING DRAWINGS



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GRAPHIC SCIENCE

JULY, 1961

THIS ISSUE 12,000 COPIES

VOLUME 3 NUMBER 7

The Magazine Serving Engineering Drawing Management—covering drafting, reproduction and microfilming, technical illustration, drawing standards and engineering documentation.

ARTICLES

DEPARTMENTS

Next Month

ELLIPSE TEMPLATES AND THEIR USE, by T. A. Thomas

Most errors in technical illustration are the result of the incorrect use of ellipse templates. Here's the solution to their mystery.

VISUAL COMMUNICATION, by Dr. Emil W. Grieshaber

With all our modern ways of making information available, pictures in many cases still can do a better job of telling us what we want and need to know.

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Letters

A Classification Problem

Sirs:

There were several articles in the May issue of *Graphic Science* that were of great interest to me. The article entitled "Draftsmen are Made —Not Born" was especially interesting and has good value when applied in large organizations.

Presently our draftsmen classifications (trainees through senior designers) are undergoing re-evaluation with regard to scope of duties and responsibilities in their respective classes. Any material that can be made available to me in this regard will be greatly appreciated.

E. L. Colageo

Chief Draftsman
Allis-Chalmers Mfg. Co.
Hyde Park Station
Boston 36, Mass.

Editor's Note: Some of our readers may be able to help Mr. Colageo. If so, write him at the above address. Also, a handbook issued by the Standards Div., U.S. Civil Service Commission, entitled "Handbook of Occupational Groups and Series of Classes," may be of help. Of particular interest would be Engineering Technician Series, GS-802 and Engineering Drafting Series GS-818. This handbook is obtainable from the Superintendent of Documents, U.S. Government Printing Office, Washington 25, D. C., for $3.00 a copy.

Society for Draftsmen

Sirs:

In your April editorial you ask, "Do we need a national society for draftsmen?" as if it were possible to give a yes or no answer to this question.

I am convinced that only when there is an unfulfilled need for such an organization, including an economic justification for it, can such a group come into being. I see the need for wide distribution of news such as you are doing in *Graphic Science*. I am not sure I see the need for a national organization. I seriously doubt if the economic justification for a national organization exists in the eyes of management who must ultimately foot the bill for the efforts involved. Truly, without deep study of the objectives of a national society, one could not do justice to your question.

There is, however, an overwhelming need in all of the drafting industry. That is, to avoid being swept into the situation where minority interests without comprehension of the full scope of our business can establish and promote points of view not in consonance with the best interests of all.

Because of the extreme breadth of our field, I am sure that no one best way exists for us. To organize a society that might lead to ill-advised pressures, be they in labor relations, military specifications, reproduction developments, or whatever else we might touch on, would be a serious mistake.

My feelings would be to keep up the good work on your distribution of news. Let new ideas filter through your editorial pages. Maybe your readership already is the membership of a national society which needs no tighter bonds than those you are now providing.

W. W. Thomas

Administrator
DEP Documentation
Radio Corporation of America
Camden 2, N. J.

Sirs:

It seems to me there are too many so-called draftsmen using the professional aspect of drafting to gain recognition in engineering. Too many novices claiming to be pros.

Drafting is what your magazine signifies; it is a graphic science with areas of specialization more numerous than most people realize. For example, descriptive geometry is but one of the many tools a draftsman needs, and yet percentagewise, very few are proficient mechanics in this exercise.

If more draftsmen would become expert in their respective fields they would have a well recognized organization which would grow through respect from business and social associates.

Before draftsmen will be recognized, organized or not, they will have to grow some merit based on ability. We need an organization. Let's not build it on sand.

William H. Damon

Chief Draftsman
McCormick Selph Assoc., Inc.
Hollister Airport
Hollister, Calif.

Sirs:

Your article, "Do we need a national society for draftsmen?" in the April issue of *Graphic Science* was extremely interesting to us. Of course, we believe that the program of The American Designers Association is the ready-made answer to the question.

Draftsmen usually have the talent, and will, if they persevere and study, eventually become designers. They are welcome to participate in our program as associate members.

Our entire program is outlined in a manual to be published this August. We will be pleased to send a copy to any of your readers who request one. A post card with their name and address and the word "manual' is all that is required. Address: The Secretary, The American Designers Association, Box 3256, Grand Central Station, New York 17, N. Y.

Harry R. Best, Jr.

Secretary
The American Designers Assoc.
Box 3256
Grand Central Station
New York 17, N. Y.

Sirs:

My answer to the question "do we need a national society for draftsmen"

is yes, but definitely. I personally believe *Graphic Science* is the one biggest step toward unity in our field. It is a terrific clearinghouse for ideas. More draftsmen should be encouraged to express themselves on their vocation.

I would be interested in knowing of a local or regional association for draftsmen in my own area. I doubt if there is one.

I am casting my vote of "keep up the good work" for *Graphic Science*.

FLOYD E. COOPER

Senior Draftsman
Maytag Company
Newton, Iowa

Training Draftsmen

Sirs:

I have read your special May issue with real interest, since I am very much interested in education and training in the technical and engineering graphics field.

Messrs. Seymour and Soroka's "Draftsmen are Made—Not Born" article was informative and well presented.

There is only one thing lacking in this issue which I thought should have been included. This thing I am referring to is the other facilities available to young men who wish to become draftsmen, but whose companies do not have a training program. I believe some time and space should be devoted to those courses which are available through technical schools (day or night) and which teach drafting only, or which have drafting and design as a major part of their curriculum.

If possible, some mention should be made of courses available through correspondence schools also. I believe that a presentation of this type would go a long way in informing aspirants to the technical fields, as well as engineering managers, of the facilities available.

A. B. VIESCAS

Engineering Department
American Machine & Foundry Co.
23 Mack Ave.
Shelby, Ohio

Types of Technical Drawings

by Franz Maria Feldhaus

This is a continuation of Chapter III of an authoritative and beautiful book, **THE HISTORY OF TECHNICAL DRAWING,** by Franz Maria Feldhaus published in 1959 by Franz Kuhlmann, K.G., of Wilhelmshaven, Germany, as **GESCHICHTE DES TECHNISCHEN ZEICHNENS.** We are indebted to the publisher for the translation, as well as for permission to republish this fascinating work. It will be continued in this department from month to month, until completed.—The Editors.

ONE MANUSCRIPT of large size produced by the Nuremberg mechanic and inventor Barthold Holzschuher in 1558 shows a portrait of the author. How much importance he attached to the compass is shown by the size of the one he is holding; in his right hand is a ruler. This ruler is shown twice as large again in the margin of the picture, and is large enough to measure all drawings in the manuscript. On the table is a square in its original form, a set square, and a cog wheel. Illustrations of cog wheels are also shown in a book lying on the ground. Holtzschuher tried to find a good shape for cogs to be used for a heavy tank that was driven by manually operated cranks from the inside. That is why he shows on one page how the teeth should be drawn. It was not known at that time that a circular shape of the tooth surface is unsuitable.

The first printed textbooks on mechanical engineering after 1540 do not show technical drawings as such. They represent machines in fairly well done artistic pictures. The textbook on mechanical engineering written by the Frenchman Jacques Besson about 1569 and published in 1578 after his death indicates the four cardinal points on each page and repeats these throughout the text when explaining the pictures. This was to show the reader where the object being described could be found in the drawing: north, south, west, or east, instead of top, bottom, left, or right.

TITLE PAGE from manuscript of mechanical designs by Berthold Holtzschuher, Nuremberg, 1558. (Library of the Germanische Nationalmuseum, Nuremberg)

The Italian Agostino Remelli presented in 1588, on 195 plates, mechanical drawings in artistic form, but they are nonetheless easy to understand. In technical books by Lorini (1592), Zonca and Zeising (1607), de Caus (1615), Verantius (1616) and Strada (1617), the same technique is used.

In the scientific journals that appeared in the seventeenth century in England, France, and Germany, many purely technical drawings are found. Jakob Leopold, once a carpenter, then theologer and mathematician, started the first technical textbook which ran into several volumes. It was really he who made sober matter-of-fact drawings of machinery popular with the numerous plates in the eight volumes. In 1760 John Smeaton, the versatile English engineer, had to make wooden models of machine parts because the working men could not work from technical drawings.

Graphic statics began with the work of Michael Varo who, as municipal secretary of Geneva, explained as early as 1584 the synthesis of mechanical powers. But only in 1864

did Carl Culmann establish the graphic static as a science, by introducing the push-and-pull curve as pressure and tension trajectors. They give a graphic picture of the power released in a body when subjected to a certain stress. Four years later Christian Otto Mohr showed the drawn representation of a curved line and four years later the art of how to represent energy in a plan was shown by Luigi Cremona. This method is used in building constructions and named after him. Wilhelm Herrmann established the graphic statics of machine mechanisms.

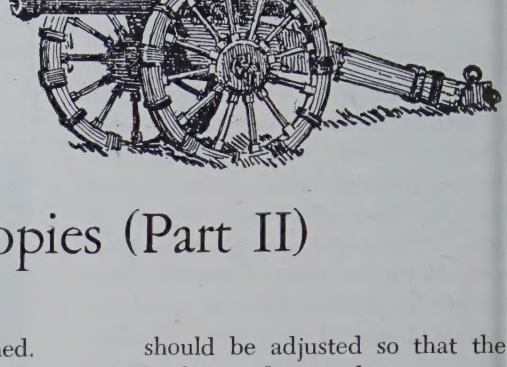
More than 35,000 symbols had to be drawn for the 3,129 plates reproduced in print by Diderot and d'Alembert between 1762 and 1782 in the most important technical work in world history, the *Encyclopédie*. The two authors put into practice the bold plan of publishing in detail the knowledge and skill of the artisan, trader, and technician as clearly as had the realizations of theology, philosophy, jurisprudence, and the art of healing been made known earlier. The encyclopédists still presented technical objects volumetrically in exterior as well as interior views. Details of machines drawn as secondary figures were drawn perspectively. Draftsmen of remarkable ability took a hand in this work. The illustrations are therefore exact and perspectively very good. The *Encyclopédie* met with great resistance from ruling circles. They realized that such a work would enlighten even the ordinary man of the lower classes. Any enlightenment would strengthen the longing for freedom of the individual. Shortly after the *Encyclopédie* was completed with the publication of its 35th volume, the French Revolution broke out which gave the middle classes their freedom. Napoleon Bonaparte was right when he said that this work had spiritually prepared the revolution.

When an artist wanted to show buildings, mines, or machines at various altitudes the drawings were fitted with folding pictures. Technicians may well have copied this method from medical men, for they had in earlier times made drawn illustrations of the human body in just such a way. The earliest folding pictures of machines may have developed around 1642.

(To be continued)

DRAFTING TRENDS

Military Engineering Documentation



by W. S. Hutchinson

Needed—Better Drawing Copies (Part II)

SOME CONTRACTORS have established documentation coordination groups. These groups centrally manage all aspects of document preparation, reproduction, and issuance. Bendix, Convair, and Hycon are examples of contractors who operate this way. At Bendix, Mishawaka, weekly meetings are held by the documentation group to trouble-shoot problems. At Hycon all documentation flows thru the drafting and shop liaison engineering group for checking and coordination to achieve centralized control.

This firm centralized control assures that all aspects of engineering documentation comply with both internal standards and procedures, and also with contractual requirements. The Bureau of Naval Weapons Technical Documentation Group meets with the Hycon and similar contractor documentation groups to assure receipt of engineering drawing copies and other data that meets the Bureau's needs.

Convair of the General Dynamics Corporation considers control over documentation so important that a new department has recently been established at Convair-Astronautics called Change Administration. The purpose of this department is to administer all change actions affecting configuration and documentation in a manner to assure that deliverable end items and spares, their technical and operational data, and control documentation are correlated and compatible.

DRAFTING STANDARDS

SO FAR I have been treating drafting as an important element of the whole engineering documentation picture. It holds a pre-eminent position in the documentation hierarchy. The actual techniques of drafting have been long established. They are covered by drafting standards and manuals by almost every company, and within the military by a series of Military Standards. We find that with the advent of newer data-processing techniques for drawing reproduction, some of the standards require revision. This is particularly true with regard to microfilming. Consequently, we have at the present time several Military Standards under revision, notably MIL-STDs-1 and 7, to incorporate changes in defense requirements. In fact, a joint services meeting has been called to reconcile recommendations for improving the quality of drawing copies made from microfilm.

Some of the more important features that are essential to the preparation of drawings that will reproduce good copies are:

1. Limit reduced size reproductions to 50% of the original size.
2. Eliminate fractional dimensioning; use only decimals.
3. Hold letters and figures in the body of a drawing to a minimum size of 3/16", or 3/32" minimum in the reduced reproduction thereof. Both dimensions and tolerances should always be the same height.
4. Employ only upright, open-style letters and figures. It is especially important to use open 4's; and 3's, 5's, 6's, and 9's with open tails similar to that of most typewriters.
5. Maintain spacing between parallel lines, and between lower case letters and figures to a minimum of .04"; upper case letters should be spaced proportionately further apart. Lower case lettering is discouraged. To provide visual uniformity, the spacing of letters should be adjusted so that the background area between any two adjacent letters is approximately equal.
6. For machine printed letters and figures, use none smaller than 12 point standard pica type, or 0.166" height.
7. Weights of lines should conform to MIL-STD-2B, paragraph 5.2.5, and MIL-STD-1A, paragraph 5.2.1. Three widths of lines are specified in MIL-STD-1A, as follows: For ink lines—thin, medium, and thick with width proportions of 1:2:4. For preprinted formats, line weights are related to typographic point standards as follows: Thin (Hairline); Medium (1-point, equals 1/72" or .013837"); Thick (2-point, equals 1/36" or .027674"). For pencil lines—No specific widths are specified in MIL-STD-1. The Standard, however, provides the following guidance: "Cutting and viewing plane lines are the thickest lines on the drawing. However, the thick lines used for outlines and other visible lines shall be sufficiently prominent to immediately differentiate them from lines used for other purposes. Hidden, sectioning, center, phantom, extension, dimension, and leader lines shall be thinner than outlines. In selecting the widths of pencil lines, consideration shall be given to the medium of reproduction involved, in order to insure proper reproduction and reduction of the thinner lines."

A recommendation of the microfilm working group for addition to this paragraph is "pencil lines regardless of width shall have the same con-

trast or degree of blackness throughout the line." The reason for this is that when pencil lines do not maintain the same contrast or degree of blackness throughout, they tend to appear on microfilm as broken lines, or may even disappear completely.

It is best to use as few different pencil hardnesses on one drawing as possible. This can be extended to widths of lines, also, using the minimum number of widths, and avoiding the very thin and very thick lines. The line width contrast of principal importance is that between the outline or visible lines and the hidden, dimension, etc., types of lines. In revising drawings, it is important that new lines match existing ones as closely as possible. One advantage of not employing heavy lines is that thinner lines are easier to erase, thus causing less damage to the drawing media. It is also advisable to use pencils that can be erased easily as heavy or abrasive erasures will remove the surface tooth and cause future reproduction problems.

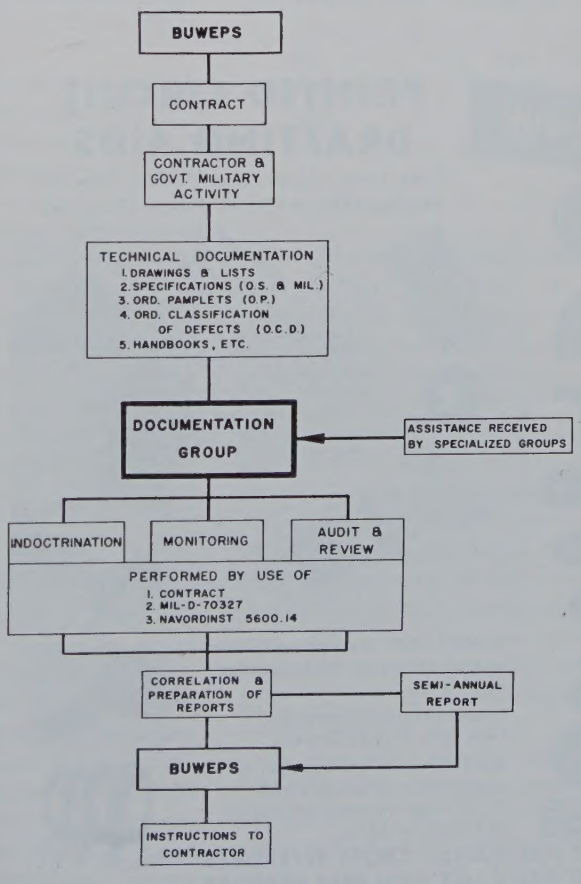
8. Many times the original pencil drawing is used to make copies instead of employing a paper negative (Vandyke), because the latter is not up-to-date or the drawing is being checked before approval.

   This practice is not recommended as it accelerates the wear and deterioration of the original. It is not necessarily the number of times a drawing is revised that determines its quality, but more often it is the number of times that the original has been used for reproduction. Careless handling and filing of originals or reproducibles are major causes of poor drawing copies. This would include folding instead of rolling drawings (flat filing is preferred), bending, dog-earring, spills, dirt, not brushing frequently while preparing, excessive humidity that causes buckling, perspiration from forearms and hands, not covering up finished portions, using drawing or reproducible media which tears easily or has poor stability. These are a few of the things to watch out for. Generally speaking, the less time a drawing is on the board, the better will be its condition. Blue grid lines printed on drafting film are of considerable aid to the draftsman in laying out his drawing and in lettering.

This is not a comprehensive coverage of drafting techniques that are essential to producing good quality drawings from which good drawing copies can be made—just some of the highlights.

As a further aid to military activities and defense contractors, we are preparing a Military Handbook to guide draftsmen and reproduction personnel in preparing good quality drawing originals and reproductions. This is yet another tool we provide to promote good drawing copies. But, standards, handbooks, and the like are not enough. It's like leading the horse to water—to achieve desired results we all must cooperate with the drafting and reproduction personnel to iron out problems, to assure ourselves that standards are being adhered to, that they are understood and correctly interpreted. This means continuous liaison, coordination of efforts, periodic checking, proper indoctrination, establishment of adequate controls with personal follow-ups. By doing all these things, we can progressively improve the quality level of drawings to a consistency that meets our needs. Your part is equally as important as ours as you produce the materials, either used for the drawing copies, or in making them. In this regard, you have a singular responsibility to see that your products are utilized to their fullest potential; that they finally result in the most acceptable and most useful end result—engineering data, the lifeline of technology.

FLOW CHART OF TECHNICAL DOCUMENTATION FUNCTION



NOTE.
ILLUSTRATES REVIEW OF COMPLETE TECHNICAL DOCUMENTATION PACKAGE. PARTIAL PACKAGES ARE REVIEWED IN THE SAME MANNER.

Notes & Comment

After School

MORE THAN a thousand graduate engineers in the state of Wisconsin were queried on their opinions of the value of engineering drawing in the light of their own industrial experience. The survey, conducted by Michael N. Besel, Assistant Professor, Engineering Drawing and Descriptive Geometry, University of Wisconsin, Milwaukee, was published in the June 1961 issue of the *Journal of Engineering Education.*

Reflecting the opinions of only graduate engineers actively engaged in engineering work, the survey showed that only 3.2% thought that recent graduates had "more than enough" background in engineering graphics. The majority of the respondents were of the opinion that recent graduates were receiving sufficient background in engineering graphics to meet the minimum demands made of them.

The majority of mechanical (55.5%) and civil (48%) engineers are of the opinion that new graduates should have had two semesters of engineering drawing. The electrical engineers are almost equally divided in their opinions concerning the question of whether one (39.5%) or two (43.5%) semesters of engineering drawing should be the minimum requirement for young engineers. The same holds true for metallurgical engineers, who divided 41.2% for one semester and 43.3% for a two-semester requirement. The majority of all engineers agreed that one semester of descriptive geometry should be a requirement.

Inking techniques, screw threads, and spring representations should, in the opinion of the engineers, be dropped from the engineering drawing curriculum.

Equipment Leasing

A PROGRAM to promote leasing and rental of its equipment is announced by Ozalid Div., General Aniline & Film Corp. Seven leasing and purchasing plans are being made available through national branches and distributor organizations. Less capital expenditures and tax advantages are cited as some of the attractive points of the program.

Haloid Changes Name

THE CORPORATE name of Haloid Xerox, Inc. has been changed to Xerox Corp. The Canadian division of the company is changed to Xerox of Canada, Ltd.

Valuable Reference

HANDSOME bound editions of *Graphic Science* Volumes 1 and 2 complete (Oct. 1959 to Dec. 1960) are now available at $25.00 each.

GRAPHIC SCIENCE
JULY, 1961
VOLUME 3, NUMBER 7

A New Look at Lists of Material

A controversial proposal for saving time and money that deserves consideration by both industry and government

by D. P. Simonton

THE PURPOSE of engineering drawings, everyone will agree, is to tell the manufacturing department how to translate a design into three dimensions and to instruct the customer on how to maintain the equipment. Traditionally, these drawings include a complete, self-sustaining list of materials itemizing everything by exact quantity and part number. This was sufficient when simple items were mass produced in large quantities on repeat orders. The drawings were complete enough to permit another manufacturer to start production without inserting additional intelligence or delay into the system. But this World War II thinking has undergone certain changes which call for reappraisal.

First of all, we aren't always making simple items any more—we're making gigantic, immensely complicated weapon systems. But, while this immensity means a tremendous scope of work, the quantity of each article of equipment may be very small, and often there are no repeat orders for these systems. Second orders often differ from first orders, making necessary new drawings. Often there is no chance to debug these designs. By the time the first few are out the door and all the fixes are down on the drawings, the job is over and a new job is in hand.

What about the drawings which are supposed to be so complete that another contractor can move in, as a stranger, and produce them? Contracts may still require this, but perhaps these requirements should be re-examined. If the day ever comes that the United States starts losing major war plants to ICBM's, there won't be time to ship drawings to other manufacturers—the war will be over by then. A job will have to be done quickly and completely, since most manufacturers have proven either unwilling or unable to work from another company's drawings.

Complex drawing systems, even though proved and carefully filed, are simply not used by maintenance men in the field. About all that actually get used in a given chassis, for instance, are the schematic, the electrical parts list, and possibly the connection list.

Let us look, then, at the present typical drawing setup, and see what it actually does for us. The usual assembly list of material contains a complete listing of the following:

1. Quantities of electrical circuit parts (resistors, capacitors, etc.)
2. Quantities of mechanical parts peculiar (chassis, gears, castings, etc.)
3. Associated drawings (schematics, assembly pictorials, etc.)
4. Quantities of special hardware (special body-bound screws, high strength bolts, etc.)
5. Specific quantities of standard hardware (standard screws, nuts, washers, etc.)
6. Specific quantities of wiring devices (cable clamps, ferrules, terminals, standoffs, ground posts, spade lugs, wire markers, etc.)
7. Specific lengths of wiring material (wire—each color code and size listed separately—bus, sleeving, etc.)
8. Sets of bulk material (solder, lubricants, adhesives, anti-sieze, lacing cord, etc.)

As a production cycle gets under way, this engineering drawing information gets worked over very thoroughly by production (assembly methods department). Any discrepancies discovered here, or anywhere else in the production department, must be fed back to engineering and then formally reflected in drawing changes. Then engineering is placed in the position of having to tell production to make the changes which production tells engineering to tell them to make. And it follows that if production can tell engineering this information, then production can also create the same information in the first place. From this, it seems logical to state these rules:

1. Requirements in which errors are primarily discoverable by engineering (resistor values, critical ground locations, etc.) should be initially specified and, when necessary, changed formally by engineering.
2. Requirements in which errors are normally discovered by production (hardware quantities, wire lengths, etc.), should be initially specified (according to engineering guide lines), and informally changed as needed by production.

PROPOSED SOLUTION

A METHOD of streamlining the drafting procedure for listing certain types of material to meet our new need in the government weapon system field could be stated thus: each individual assembly drawing (list of material and pictorial) would continue to itemize all electrical parts, mechanical parts peculiar, special hardware, and special wiring material associated pictorials; would delete all reference to standard hardware, wiring items, and bulk material; and would list references to a standard project assembly specification and wiring specification (each with a drawing number).

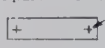
A standard assembly specification drawing lists drawing numbers (no quantities) of all standard hardware (in terms of part numbers) items together with specific rules for their selection and installation.

A standard wiring specification lists drawing numbers (again, no quantities or lengths) of all standard

ASSEMBLY SPECIFICATION

1. SCOPE: When referenced by an Assembly Drawing, this Assembly Specification supplements such Assembly Drawing to specify the selection and installation of certain items of hardware which are itemized herein and which are not itemized on the Assembly List of Material. Where the requirements of this Assembly Specification conflict with those of the Assembly Drawing, the Assembly Drawing shall govern.

2. HARDWARE: When the governing Assembly Pictorial indicates the requirement for an attaching hardware assembly as shown in Figure A below, hardware of the size indicated (in the illustration, #6-32) shall be selected and installed in accordance with the requirements below.

Figure A 

2.1 SCREWS shall be selected from the drawings listed in Table D. Table D shall be used as a guide in selecting specific screw part numbers(and implicit lengths). Where special requirements or tolerances buildups cause conflict between par 2.1.1 or 2.1.2 and Table D, par 2.1.1 or 2.1.2 shall govern.

2.1.1 Screws in through-thread applications shall provide a minimum projection of 1½ threads and a maximum projection limited by the next larger standard length beyond the nut or mating thread. This requirement does not apply to the threads of mounting studs which are integral with a part.(E.g; Transformer mounting studs)

2.1.2 Blind Tapped Hole engagement shall conform to the following:

a. In Non-Metals -- 3 times the screw diameter or 75% of the threaded depth of the hole, whichever is less.

b. In Metals -- 1½ times the screw diameter. Table D, Fig. 5 thru 9 have been computed on this basis.

2.1.3 Direction of Mounting shall provide for thread projection into the inside or wired side of chassis enclosures wherever possible.

2.2 NUTS shall be selected from the following table B:

	Hex Nut, Steel, Cadmium Plated, Complies with MIL-E-4158		Hex Nut, Stainless Steel(18-8) Complies with MIL-E-16400	
SIZE	Non-Locking	Locking, Miniature	Non-Locking	Locking, Miniature
#4-40	RCA57453-703	MS-21042-04	NAS 671C4	NAS 1291C04M
#6-32	-704	-06	6	6M
#8-32	-705	-	8	-
#10-32	AN 315-3R	-	AN 315C3R	-
¼-28	-4R	-	" 4R	-

2.2.1 Non-Locking Nuts shall be used throughout except as noted in 2.2.2. Note that Table D is based upon the use of non-locking nuts.

CLASSIFICATION | DWG. A SIZE

REV. | CODE IDENT NO. 49671 | SHEET

FIG. 1—Page 1 of suggested format for assembly specification.

2.2.2 Self-Locking Nuts shall be used only to mount miniature tube sockets, relay sockets, DPD or DPX type connectors and similar applications in which standard pattern nuts and washers will not fit. See Table D, Figure 4.

2.3 WASHERS shall be selected from the following Table C.

Size	Flat Washer Stn Stl	Lockwasher, Split Ring, Monel	Lockwasher, External Tooth Phosphor Bronze, Tinned
#4	AN960-C4L	MS-35338-116	MS-35335-71
#6	-C6	-117	-72
#8	-C8	-118	-73
#10	-C10L	-119	-74
¼	AN960-C416	MS-35338-120	MS-35335-75

2.3.1 Flat Washers shall be used under the following conditions. (See also Table D, figures 2, 3, 6, and 11.

a. To provide bearing surface over slotted or enlarged holes.(i e; larger than the standard multiple clearance holes .147 for #4, .173 for #6, .199 for #8, .228 for #10, .297 for ¼)

b. To protect soft materials or painted surfaces from screw heads or lockwashers, except that no flat washer shall be used between a screw head and a painted surface when the screw is not turned in removing the part which it retains.

c. To protect any surface from a screw head or lockwasher which must be removed or manipulated in normal maintenance. This includes aluminum surfaces in outdoor applications.

2.3.2 Split Lockwashers shall be used to secure non-locking nuts in all standard screw assemblies and to secure screws in fixed, tapped holes.(except for flat head screws and as noted in 2.3.3) See Table D, Figures 1, 2, 3, 5, 6, 9, 10, and 11

2.3.3 External Tooth Lockwashers shall be used between ground posts (or other parts requiring a secure electrical contact) and the mounting surface.

2.3.4 Staking Compound (RCA 2016075-1, applied per Manufacturing Specification 20203A2) shall be applied to permanently installed setscrews and to flathead screws which cannot be secured by a lockwasher or lockmut. See Table D, Figures 7 and 12

2.4 HARDWARE SUPPLIED WITH VENDOR PARTS shall be used as supplied unless otherwise specified.

2.5 FASTENERS EXPOSED ON UNIT EXTERIORS

2.5.1 When manipulated in normal maintenance such fastener shall be designated by marking an anular ring on the surface surrounding the fastener. The fastener itself shall retain its standard finish.

2.5.2 When Not manipulated in normal maintenance such fastener shall be finished to to match the surrounding surface.

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FIG. 1—Page 2

wiring materials together with rules for selection and installation.

In each case these listings would appear once, rather than repeatedly, on each individual list of material and pictorial. Fig. 1 shows a suggested format for the assembly specification. Fig. 2 shows a suggested format for the wiring specification.

Assembly and Wiring Specifications

Engineering drafting effort on the initial preparation of lists of material and assembly pictorials would be reduced by nearly 30%, since none of the standard items has to be specifically determined, listed, or located on individual drawings. Mechanical assembly pictorials would be simplified by the removal of a large number of the standard hardware callouts (leaders and balloons). The preparation of instruction book drawings would be greatly simplified, and subsequent engineering change effort on assembly pictorials and lists of material would be reduced by 40%.

At present a large percentage of all such changes are required merely to correct picayune errors. The remaining changes would be correspondingly expedited because they would not have to compete for the time of engineers, draftsmen, drafting clerks, etc. Those involved in the changes would be production control and ordering clerks, cost estimators, accountants, expeditors, and others.

Blueprint costs would be reduced, deliveries expedited, and files condensed through reduction in bulk of the multitude of lists of material. Design release schedules would be expedited by the proposed innovation, where in the past final production release has been delayed, awaiting the detailed itemization of all hardware and wire information. The confusion, duplicate ordering, and large volume of paperwork inevitably resulting from partial and conditional releases would be minimized when lists of material contained only the essential peculiar items of procurement in one clean release.

Currently, a change in hardware or wiring standards can trigger a fantastic quantity of paperwork in engineering and in production, the cost of which is many times that of the material involved. The recommended alternate would permit such a change

by a single, comparatively simple revision to the one standard assembly or wiring specification drawing.

Efficient bulk ordering would be facilitated by the use of standard hardware and wiring specifications for all assemblies. Delays in production due to the time required for a formal drawing-change approval from engineering would be eliminated, since the change action on standard items becomes the responsibility of the assembly department. The final drawing cleanup, required at final inspection of the first production assembly, could be eliminated or at least greatly simplified.

How It Can Be Done

Production (assembly methods) is facilitated to select quantities and lengths of the standard items initially required. They presently must check most of these items anyway before release to the assembly floor. Schedules permit this selection and procurement (mostly short-term items) during the purchasing and fabrication cycles, before assembly. As the job progresses, assembly methods advises production control (informally and directly instead of via design engineering and the change cycle) of any necessary adjustment in quantities and types of material.

Production control extends the list of items which are bulk ordered and maximum-minimum stocked, obtaining bulk quantities from assembly methods instead of exact quantities from design engineering. Adjustments in quantities and types also come, from methods instead of design engineering, through the course of the job. The usual process of requiring formal correction to the lists of material before official factory action can be taken has always been bottlenecked by the engineering change cycle. Yet necessary information can be obtained on-the-spot from a methods engineer if the traditional system is changed to permit it.

Purchasing procures economical bulk quantities of material to replace stock-room depletions rather than ordering fixed small quantities. This policy becomes even more advantageous as integrated DoD general design specifications become more and more tied to AN and MS drawings, and concomitantly as projects require fewer and fewer different types of standardized material.

3. STANDOFF TERMINALS: When designated on the governing Assembly Pictorial by a reference designation in the form "E12(I)" (I.e; 'Terminal #12, Insulated').terminal RCA 486011-10 shall be installed in accordance with 2.1.2.b./Table D,#6-32,Fig. 4.

4. GROUND POST TERMINALS: When designated on the governing Assembly Pictorial by a reference designation in the form "E13 (G)" (I.e; 'Terminal #13, Ground'), terminal RCA 89TLP7M-1 shall be installed in accordance with 2.1.2.b. and 2.3.3 Screw lengths are indicated by Table D, #4-40,

5. CABLE CLAMPS shall be installed as suggested on the Assembly Pictorial or as determined at Assembly. Clamps shall be installed near each cable bend and major cabling break out. Clamp sizes and quantities shall be such as to prevent undue movement of the cable during handling, maintenance and operation. Cable clamps shall be selected from the following Table E.

Cable Dia	Plastic Cable Clamp Part Number	Cable Dia	Metal Cable Clamp Part Number
1/8	MS-25281-2P	1 1/16	MS-21919 DG-17
3/16	-3P	1 1/8	-18
1/4	-4P	1 3/16	-19
5/16	-5P	1 1/4	-20
3/8	-6P	1 5/16	-21
7/16	-7P	1 3/8	-22
1/2	-8P	1 7/16	-23
9/16	-9P	1 1/2	-24
5/8	-10P	1 9/16	-25
11/16	-11P	1 5/8	-26
3/4	-12P	1 3/4	-28
13/16	-13P	1 7/8	-30
7/8	-14P	2	-32
15/16	--15P	2 1/8	-34
1	MS-25281-16P	2 1/4	-36
		2 3/8	-38
		2 1/2	-40
		2 3/4	-44
		3	-48
		3 1/4	-52
		3 1/2	-56
		4	MS-21919DG- 64

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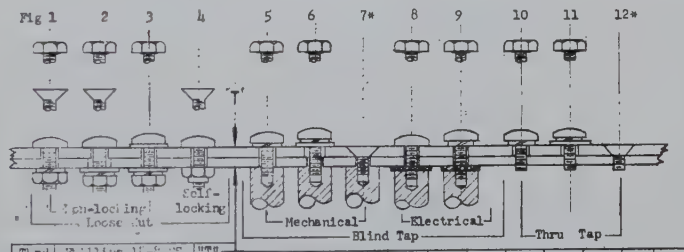
FIG. 1—Page 3

TABLE D The following figures and table shall be used as a guide in the selection of screws by length from the drawings indicated: (* see Par 2.3.4.)



Thrd Size	Phillips H.D. MS Panhead (Drawing Number)	Flathead	Up to Fig	.062	.125	.187	.250	.312	.375	.437	.500	.562	.625	.687	.750
				(Part Dash Number)											
4-40	8911387	8954980	12				7	9	11	13	15	15	17	17	19
			10,11				9	11	13	15	15	17	17	19	19
			1,4,7	5	7	9	11	13	15	15	17	17	19	19	21
			2,3,5 6,8,9	7	9	11	13	15	15	17	17	19	19	21	21
6-32	8911387	8977828	12				7	9	11	13	15	15	17	17	19
			10				9	11	13	15	15	17	17	19	19
			11,7	5	7	9	11	13	15	15	17	17	19	19	21
			1,4,5,8	7	9	11	13	15	15	17	17	19	19	21	21
			2,3,6,9	9	11	13	15	15	17	17	19	19	21	21	23
8-32	8911448	8977889	12				7	9	11	13	15	15	17	17	19
			10					11	13	15	15	17	17	19	19
			11					13	15	15	17	17	19	19	21
			1,7	7	9	11	13	15	15	17	17	19	19	21	21
			2,4,8	9	11	13	15	15	17	17	19	19	21	21	23
			3,6,9	11	13	15	15	17	17	19	19	21	21	23	23
10-32	8911379	8977827	12					9	11	13	15	15	17	17	19
			10					11	13	15	15	17	17	19	19
			11					13	15	15	17	17	19	19	21
			1	7	9	11	13	15	15	17	17	19	19	21	21
			2,7	9	11	13	15	15	17	17	19	19	21	21	23
			3,5,8	11	13	15	15	17	17	19	19	21	21	23	23
			6,9	13	15	15	17	17	19	19	21	21	23	23	25
1/4-28	Hex Head Bolt NAS 501-4		1	3	3	4	5	6	6	7	7	10	10	11	11
			2,8	3	4	5	5	6	6	7	7	10	10	11	11
			3,9	4	5	5	6	6	7	10	10	10	11	11	12
			5	5	6	6	6	7	7	7	10	10	11	11	12
			6	5	5	6	6	7	7	10	10	11	11	12	12
			10							5	5	6	6	7	7
			11							5	6	6	7	7	10

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FIG. 1—Page 4

WIRING SPECIFICATION

1. SCOPE: When referenced by a Wiring Connection List, this Wiring Specification supplements such Wiring Connection List to specify the selection and installation of certain wiring and wiring devices which are itemized herein and which are not itemized either in the Wiring Connection List or in the Assembly List of Material. Where the requirements of this Wiring Specification conflict with those of the Wiring Connection List, the Wiring Connection List shall govern.

2. WIRING CONNECTION LIST referencing this Wiring Specification will conform to the sample shown in Figure I. Significance of columns is as follows:

Line: Printed in numerical sequence on each sheet. The complete identification of any conductor is thus (page number) - (line number) of its first entry.

Code: Refers to one of the following:
a. Reference designation of an electrical part mounted point-to-point between terminals. Such parts are itemized in the governing Assembly List of Mat'l.
b. Wire Item. Item numbers less than 100 refer to wire part numbers itemized in Table II below. Item numbers higher than 100 refer to non-standard wire itemized in the governing Wiring Connection List.

CC/PN: Color Code/Part Number of the wire item. In Table II, when an item in the "Part Number" column shows no definitive part - dash number, the "CC/PN" number shall be used to complete the identification of the wire item. E.g; Code 11, CC/PN 94 means RCA 999101-94 (AWG#22, White base, yellow stripe wire) The color code of the wire tracer may also be read form the CC/PN in accordance with standard color/number convention. To confine this entry to two digits, the base number (9-white) is omitted from the CC/PN of double stripe wires. E.g; "02" implies "902". See also the reference Table III herein.

Fig: Refers to the method of terminating the wire. The termination figure consists of two characters, significance of which is indicated below:
First Character (alphabetical refers to the method of securing the conductor in accordance with the specifications appearing in Table IV

Fig	Type of termination	Fig	Type fo termination
-	Colder	G	Hypen Socket
A	Flanged Spade	H	Crablok Ferrule
B	Ring	J	Coax, Modulok, Plug
C	Right Angle Ring	K	Coax, Modulok, Receptacle
D	Flag	L	Coax, Connector, Plug
E	Taper Pin	M	Coax, Connector, Receptacle
F	Hyphen Pin		

Second Character (Numerical) refers to marking or shield termination in accordance with the specifications appearing in table V

Fig	Sleeve or terminater
-	No sleeve or terminator
1	Marker Sleeve
2	Plain Sleeve
3	Grounded Terminator Ferrule for Shielded or Coax Wire -- with Marker
4	Grounded Terminator Ferrule for Shielded or Coax Wire -- no Marker
5	Plain Terminator Ferrule for Shielded or Coax Wire - - with Marker
6	Plain Terminator ferrule for Shielded or Coax Wire -- no Marker

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FIG 2—Page 1 of suggested format for wiring specification.

WIRING SPECIFICATION (Continued)

From: Reference Designation and terminal number at which one end of the wire is secured. "From" entries are listed in alpha-numerical sequence. An asterisk (*) indicates that the wire has been listed previously (This will occur when the "To" entry is alpha-numerically smaller than the "From" entry. Each wire is listed twice, once from each end.)
When the "From" entry is that of a connecting element, the next line in the "From column will show, in parentheses, the reference designation of its mate.
E.g; A7P1 -1 Assembly 7, Plug 1 - pin 1.
(A3J1)-2 (Mates with Assembly 3, Jack 1)- pin 2.
Note that the pin numbers apply equally to both plug and jack, but that wiring for A3J1 will appear on the Wiring Connection List for "A3" Assembly.

To: Reference Designation and terminal number at the opposite end of the wire. "To" entries are not alpha-numerical in sequence.

Wire Route: Follows the cable leg designations shown on the Assembly Pictorial.

Lead Designation/Name of Function: Refers to Logic Diagrams and Maintenance Block Diagrams. Not a part of the Manufacturing information.

Remarks: Code to associate related conductors. E.g; In Figure I, lines 22 thru 25 represent the first, second and third conductors and the shield respectively of a twisted triplet, shielded cable. They are associated by the code AAA. The next associated grouping would bear the code AAB, etc.

FIGURE I SAMPLE CONNECTION LIST

Line	Code	CC PN	Fig	From	To	Fig	Route	Lead Designation	Name of Function	Remarks
					Typical Chassis From/To List					
1	52	9	B3	C12-1	TB3-14	-5	ABED			
2	12	04	B1	C12-2	E4	—	P			
3	12	04	—	*E4	C12-2	B1	P			
4	R7		-2	E6	E7	—	P			
5	103		-3	E6	TB3-14	-5	CED			
6	R7		—	*E7	E6	-2	P			
					Typical Cabinet From/To List					
17	52	90	E5	A2P1-1	A6P12-1	E4	BEDH	3TR7106	2 SP-16TX-ACC, MODE	
18	52	90	E4	*A6P12-1	A2P1 -1	E5	HDED	3TR7106	2 SP-16TX-ACC, MODE	
19	41	02	E1	A7P1-1	A9TB2-12	H1	CFH	2TR2106	AGC Bus	175A9TB3-1
20	41	03	E1	(A3J1)-2	A7P2-2	E1	CDA	1TR1007		
21	101		E5	-3	A7P2-16	E3	C			
22	67	1	H1	TB1-1	A2XA5-1	G1	ABC			AAA
23	67	2	H1	TB1-2	A2XA5-2	G1	ABC			AAA
24	67	3	H1	TB1-3	A2XA5-3	G1	ABC			AAA
25	67	S	H3	TB1-4						AAA

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FIG 2—Page 2

Maximum-minimum stocks are extended to include more items and controlled stocks will be correspondingly reduced. These items are distributed on a more flexible basis than formerly in order to support assembly floor requirements,

The assembly floor refers standard hardware and wire problems to methods instead of engineering. This alleviates the old communications problem of contacting engineers and getting them onto the floor to follow their jobs.

Quality control inspects finished assemblies to drawings which do not tie quality down so rigidly to exact nut and screw requirements, but permit inspection for more significant intent-type items.

The provisioning parts breakdown conventionally lists under each assembly indenture the exact part number and quantity of each part in that assembly—a direct copy from the equipment lists of material. The quantities are then totaled for each item in the entire equipment, multiplied by a guide-line factor, and the standard hardware and wiring items are rounded off to the nearest hundred (or gross) and bulk ordered for spare part requirements.

This same end result may be approximated, however, from the actual quantities consumed on the floor during the equipment manufacturing cycle—and this is entirely possible (even facilitated) by use of the assembly and wiring specifications. The further desirability of this latter method may be seen when we consider that the items involved are nuisance items with standard usage throughout the equipment and that the number of entries on the PPL will be reduced approximately 30% by the elimination of the many same as-above items now required.

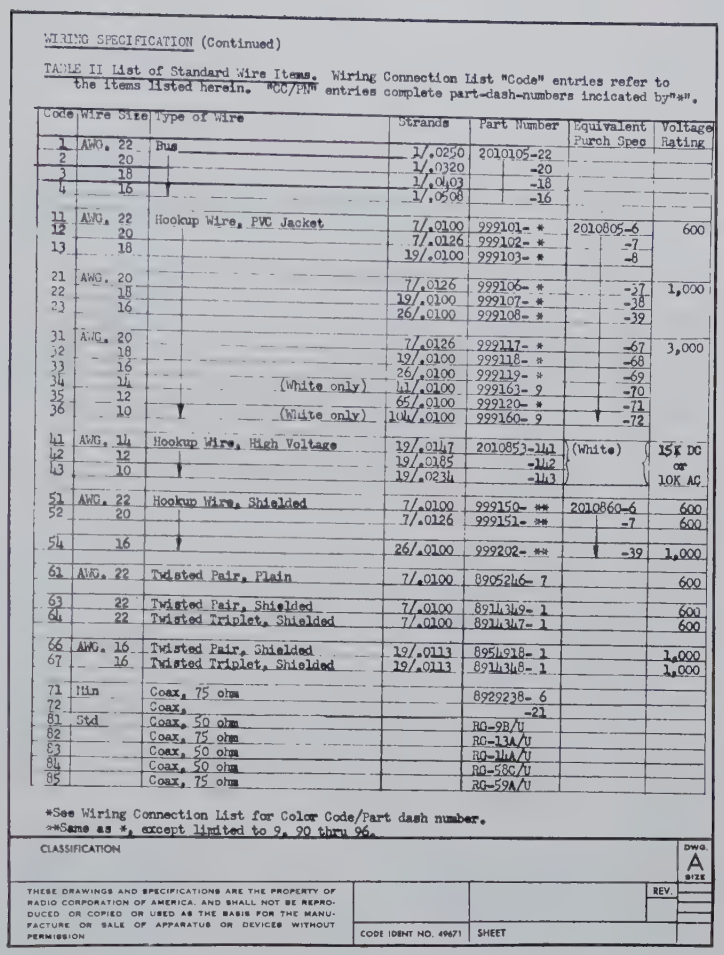
The illustrated parts breakdown conventionally depicts each assembly by an exploded, isometric view with federal stock number callouts for each part. Assembly and wiring specifications can be translated into military logistics terminology, reproduced in the maintenance handbook and implemented in any easy-to-use manner. Maintenance men in the field can be provided with a kit of these standard items, replenishable out of local standard stock, together with a simple set of rules and tools for their application. The conven

tional method treats a #6-32 screw with the same formality as a special transformer, requiring reference to an illustrated parts breakdown to find the FSN of each item in an assembly, and a trip to a stock room for its procurement. Actual practice in the field most certainly bypasses such a procedure.

Military Specifications

Military drafting specifications present a problem. There appear to be three distinct situations in this regard:

1. The R&D program which requires no engineering data submission, or at most an informal, abbreviated submission. In this case, contractor drawings need be only complete enough to meet internal procurement requirements. Therefore the assembly and wiring specification technique may be used without restriction.
2. The semi-formal end item program which does require engineering data submission, but for which the military agrees to waive the requirement for documentation of exact part number and quantity of certain standard items for each application in each assembly. In this case, the assembly and wiring specification will suffice for design, equipment procurement, and engineering data submission. The procuring service, however, must relax the logistics documentation requirements to the extent discussed previously. The procurement document, of course, must reflect the relaxation—or a waiver obtained very early in the program. RCA has worked with the the U.S. Marine Corps on the AN/UPS-1 on just this basis. The results have been extremely gratifying for all concerned.
3. Formal, full-scale program requiring complete adherence to all drafting and logistics documentation requirement. When the procuring service refuses to allow any relief in these areas, the assembly and wiring specification technique can still be used to good effect during the equipment procurement phase. The assembly department can be allowed full latitude to select and install suitable standard



WIRING SPECIFICATION (Continued)

TABLE II List of Standard Wire Items. Wiring Connection List "Code" entries refer to the items listed herein. "CC/PN" entries complete part-dash-numbers incicated by"*".

Code	Wire Size	Type of Wire	Strands	Part Number	Equivalent Purch Spec	Voltage Rating
1	AWG. 22	Bus	1/.0250	2010105-22		
2	20		1/.0320	-20		
3	18		1/.0403	-18		
4	16		1/.0508	-16		
11	AWG. 22	Hookup Wire, PVC Jacket	7/.0100	999101- *	2010805-6	600
12	20		7/.0126	999102- *	-7	
13	18		19/.0100	999103- *	-8	
21	AWG. 20		7/.0126	999106- *	-37	1,000
22	18		19/.0100	999107- *	-38	
23	16		26/.0100	999108- *	-39	
31	AWG. 20		7/.0126	999117- *	-67	3,000
32	18		19/.0100	999118- *	-68	
33	16		26/.0100	999119- *	-69	
34	14	(White only)	41/.0100	999163- 9	-70	
35	12		65/.0100	999120- *	-71	
36	10	(White only)	104/.0100	999160- 9	-72	
41	AWG. 14	Hookup Wire, High Voltage	19/.0147	2010853-141	(White)	15K DC or 10K AC
42	12		19/.0185	-142		
43	10		19/.0234	-143		
51	AWG. 22	Hookup Wire, Shielded	7/.0100	999150- **	2010860-6	600
52	20		7/.0126	999151- **	-7	600
54	16		26/.0100	999202- **	-39	1,000
61	AWG. 22	Twisted Pair, Plain	7/.0100	890526- 7		600
63	22	Twisted Pair, Shielded	7/.0100	8914349- 1		600
64	22	Twisted Triplet, Shielded	7/.0100	8914347- 1		600
66	AWG. 16	Twisted Pair, Shielded	19/.0113	8954918- 1		1,000
67	16	Twisted Triplet, Shielded	19/.0113	8914348- 1		1,000
71	Min	Coax, 75 ohm		8929238- 6		
72		Coax,		-21		
81	Std	Coax, 50 ohm		RG-9B/U		
82		Coax, 75 ohm		RG-13A/U		
83		Coax, 50 ohm		RG-14A/U		
84		Coax, 50 ohm		RG-58C/U		
85		Coax, 75 ohm		RG-59A/U		

*See Wiring Connection List for Color Code/Part dash number.
**Same as *, except limited to 9, 90 thru 96.

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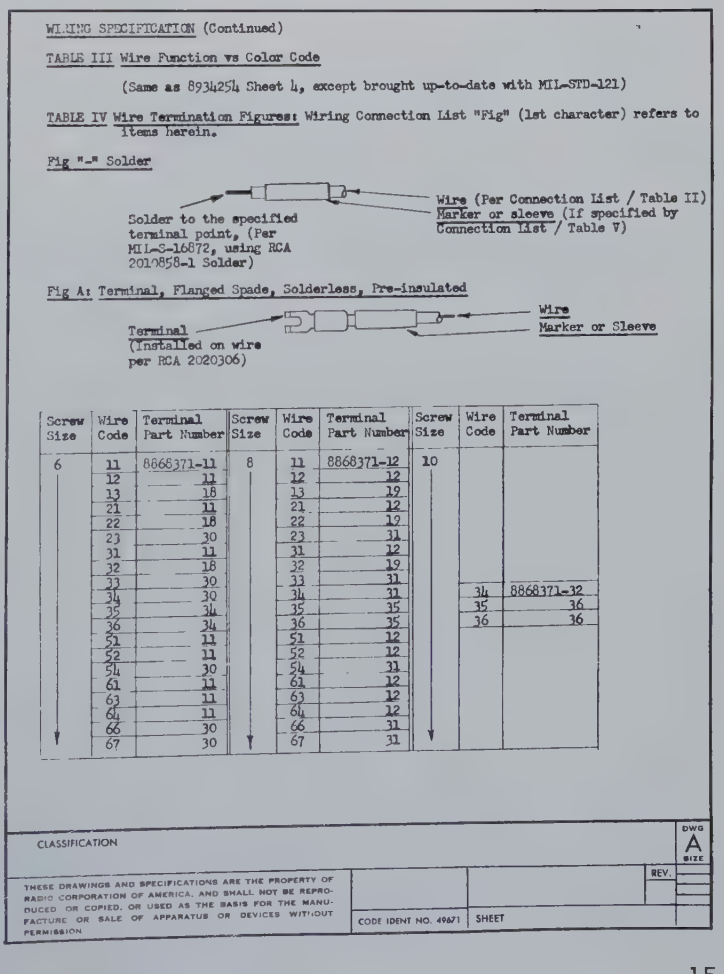
FIG. 2—Page 3



WIRING SPECIFICATION (Continued)

TABLE III Wire Function vs Color Code

(Same as 8934254 Sheet 4, except brought up-to-date with MIL-STD-121)

TABLE IV Wire Termination Figures: Wiring Connection List "Fig" (1st character) refers to items herein.

Fig "-" Solder

Solder to the specified terminal point, (Per MIL-S-16872, using RCA 2010858-1 Solder)

Wire (Per Connection List / Table II)
Marker or sleeve (If specified by Connection List / Table V)

Fig A: Terminal, Flanged Spade, Solderless, Pre-insulated

Terminal (Installed on wire per RCA 2020306)

Wire
Marker or Sleeve

Screw Size	Wire Code	Terminal Part Number	Screw Size	Wire Code	Terminal Part Number	Screw Size	Wire Code	Terminal Part Number
6	11	8868371-11	8	11	8868371-12	10		
	12	11		12	12			
	13	18		13	19			
	21	11		21	12			
	22	18		22	19			
	23	30		23	31			
	31	11		31	12			
	32	18		32	19			
	33	30		33	31			
	34	30		34	31		34	8868371-32
	35	34		35	35		35	36
	36	34		36	35		36	36
	51	11		51	12			
	52	11		52	12			
	54	30		54	31			
	61	11		61	12			
	63	11		63	12			
	64	11		64	12			
	66	30		66	31			
	67	30		67	31			

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FIG 2—Page 4

WIRING SPECIFICATION (Continued)

Table V: Sleeve and Terminator Figures: Wiring Connection List "Fig" (second character) entries refer to the items herein:

Fig - : No Sleeve or Terminator required.

Fig 1. Wire Markers for cabinet and chassis wiring shall be made from lengths (either 1.1 ± .1 or 0.6 ± .1 inch) of sleeving selected from RCA2010823. The part-dash-numbers (and implicit diameters)shall be selected from table below. Each marker shall be permanently and legibly marked with the number of the terminal of the part at which the wire is to be terminated. (E.g; Wire terminating at R21, terminal 2 shall be marked "2").

Fig 2 Sleeving for electrical protection of terminations shall be selected from RCA 2010823 as in Figure 1 above, except that no marking shall be applied.

Wire Code	Sleeving Part-dash numbers to be used with various wire combinations: Single wire	
1	2010823-451	
2	452	
3	453	
4	454	
11	455	1 or 2 on 8935197 Relay; use 460. 1 or 2 on 759338 Relay; use 459
12	456	1 or 2 on 759338 Relay or on 430351 Lampholder; use 459. 1 or 2 on 8935197 Relay; use 460
13	457	
21	458	
22	459	
23	460	
31	460	
32	461	
33	462	
34	463	
35	465	
36	466	
41		
42		
43		
*51	455	
*52	456	
*54	460	
61	455 (2)	
*63	455 (2)	
*64	455 (3)	
*66	460 (2)	
*67	460 (3)	
*71	456	
*72		
*81		
*82		
*83		
*84	465	
*85	467	

*Apply only to protective sleeving (Fig 2). Markers are specified in Figures 3 & 5.

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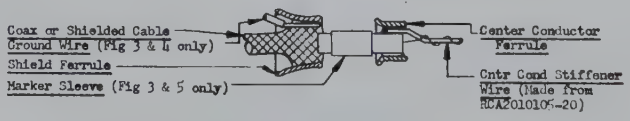
FIG. 2—Page 5

WIRING SPECIFICATION

TABLE V: Sleeve and Terminator Figures (Continued)

Fig 3: Terminator Ferrule, Shielded or Coax, Grounded, With Marker
Fig 4: " " " " " " No Marker
Fig 5: " " " " Ungrounded, With Marker
Fig 6: " " " " " " No Marker

(This Pictorial Applies to Figures 3, 4, 5 and 6)



Wire Code	Shield Term Part Number	Cntr Cond Fl Part Number	Marker (Fig 3 & 5 only) Part Number
51	8950905-5	N/A	2010823-455
52	5		456
54	7		460
63	7		455(2)
64	9		455(3)
66			460(2)
67			460(3)
71	5	8916355-7	456
72	7	8	
81		N/A	
82			
83			
84	9		465
85	10		467

CLASSIFICATION

DWG. A SIZE

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REV.

CODE IDENT NO. 49671 SHEET

FIG. 2—Page 6

hardware, wire, and wiring devices without the need for formal internal documentation. At an appointed time later in the procurement cycle, however, a liaison program can be set up to provide feedback of actual usage from the assembly department to drafting. At that time, the drawings can be completed for input to the documentation groups. The important point here is that usable engineering drawings can be released for procurement at a much earlier time and the factory is relieved of about 15% of the usual paper work. If the detail logistics documentation must be generated concurrent with the equipment, then the assembly and wiring specifications can still be used as a manufacturing and inspection guide, allowing the assembly department to proceed in spite of detail drawing errors and to feed back the discrepancies to engineering drafting without holding up production.

The drawing index, itemizing all drawings to be delivered on the contract, still itemizes the drawings of all the parts involved. In the case of the standard attaching item drawings, they will be listed completely on the assembly specification (once), rather than on the individual lists of material. Thus, the preparation of the drawing index is simplified.

Summary

In line with industry's general cost reduction programs, this proposal deserves serious consideration both by industry and by the military. It can save a great deal of time and money for all activities.

The use of an assembly and wiring specification holds particular promise of saving on low quantity, deliverable prototypes. It is time to stand back and look at our situation realistically, not only as contractors trying to make a profit, but as a country trying to survive. And revising a little thing like a list of material is one way to start doing it.

The Author

D. P. Simonton is manager of design support services at RCA's Missile and Surface Radar Engineering Plant in Van Nuys, Calif.

FUNCTIONAL DRAFTING

The draftsman must convey information in clear unmistakable terms—his operations may be made more efficient; they cannot be made "simple"

E. L. Seeland and P. B. Davis

Six years ago the design and drafting department of Ebasco Services Incorporated, New York, a firm of engineers, constructors, and management consultants, inaugurated a crash program designed to streamline its drafting operations. The initial step—and the one which proved to be the backbone of the operation—was the introduction of what was then known as simplified drafting. It was a new concept in a tradition-bound field and consisted essentially of a more efficient method of delineation in which every line and every letter on a drawing was put there for a practical and necessary purpose. Under no circumstances did this imply that the all-important element of clarity in a drawing was to be sacrificed. Today, this method is referred to as functional drafting, which is a much more appropriate designation. The operations of the draftsman may be made more efficient; they cannot be made simple.

Why Functional Drafting?

The primary purpose of functional drafting is to reduce costs. There are, however, two important corollaries to this statement. They are (1) the conservation of manpower and (2) the maximum utilization of creative brainpower. By the elimination of wasteful drafting operations, more men are made available to perform the essential, creative functions that go into the preparation of a drawing. The end product of the draftsman's effort is not the drawing itself, but the structure which will be built or the product that will be manufactured from that drawing. It is a means to an end and as such should be stripped of all unnecessary frills and artistic effects which serve no constructive purpose. This type of economy is particularly important in this modern technological age which demands the most efficient use of technical manpower. Furthermore, with construction projects growing in magnitude and complexity and with costs becoming more and more critical, draftsmen must devote more of their time to creative thinking, thus improving their productivity and value to their organization.

From several typical jobs it was determined that the total engineering cost was divided as follows: general engineering 30%, and design-drafting 70%. These proportions will vary among organizations depending upon their method of work division and job classification. The dividing line between engineering and drafting is often quite flexible and indeterminate. In some instances, a considerable amount of engineering work may be performed by the drafting department and the cost charged against drafting. In other instances, the reverse may be true with a resulting lower percentage of total cost attributed to drafting. However, the important point is that, under ordinary circumstances, the larger portion of the engineering cost of a project is subject to sound cost reduction methods such as functional drafting, with resultant savings that can be of substantial portions.

Organization and Training

The design-drafting department at Ebasco is headed by a superintendent and is divided into five divisions: architectural-structural, concrete-hydraulic, electrical, mechanical, and industrial—each with a division chief in charge. The staff in each division is divided into squads of proper size to suit job requirements, and each is supervised by a squad leader. The squad is composed of designers and draftsmen.

As the program began to take shape certain individuals in each division, in addition to the supervisors, were selected and trained in the practices and principles of functional drafting. These specialists were carefully chosen by personality, temperament, and know-how, to help sell this new concept to the design-drafting department personnel.

A motion picture entitled "The Principles and Concepts of Functional Drafting"[1] was acquired to facilitate the indoctrination of newly appointed designers, draftsmen, and engineers.

Putting the Program Into Effect

The first step was to obtain the support of top management, since resistance to the new look in drafting was anticipated not only from the designers and draftsmen, but also from other departments within the company. Some difficulty with the construction department, particularly, was expected, but none was encountered. It accepted the program in principle because it was aware of the benefits to be derived by the field forces in working with drawings devoid of unnecessary details and superfluous linework. It was empha-

[1] Produced by Industrial Education Institute. Technical Supervision by Paul B. Davis of Ebasco Services Incorporated and Don Fuller of H. K. Ferguson Company.

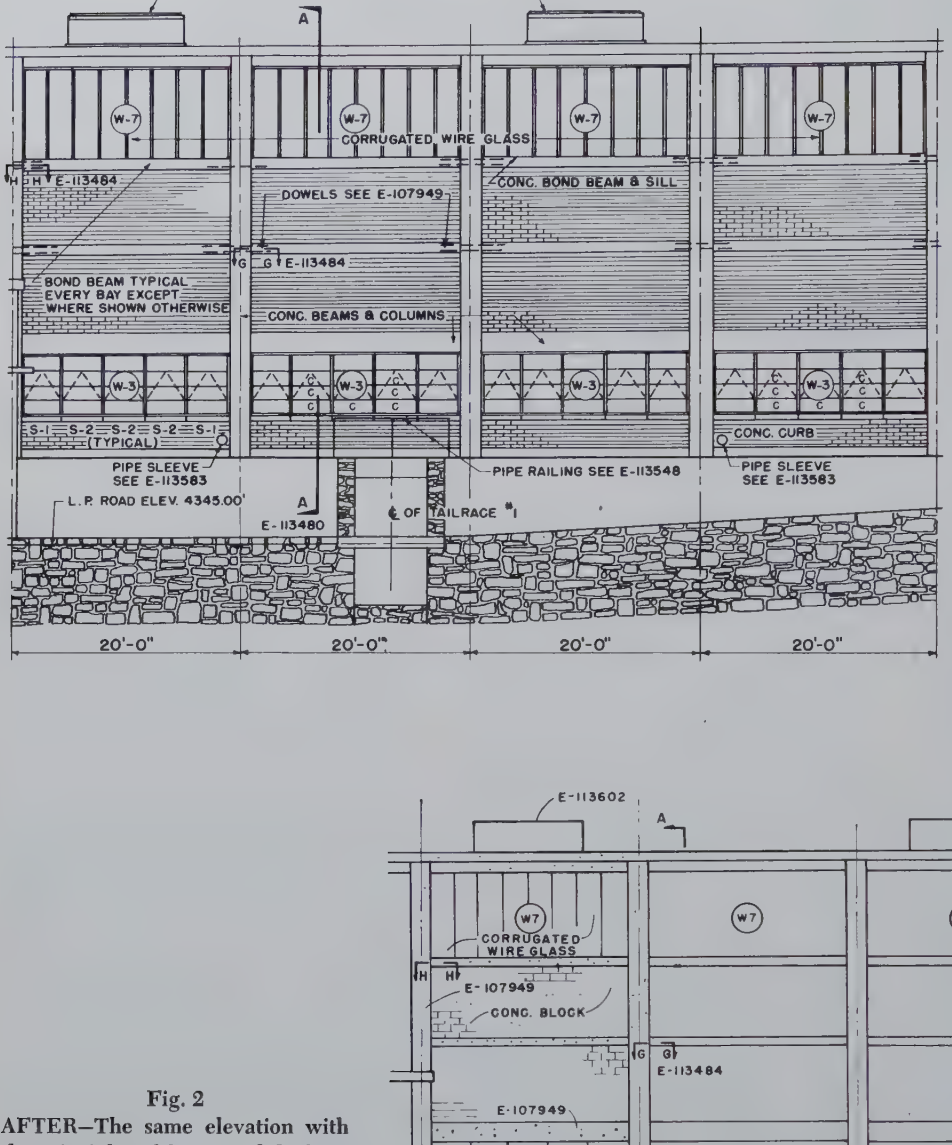


Fig. 1
BEFORE—Exterior building elevation at the start of the functional drafting program.

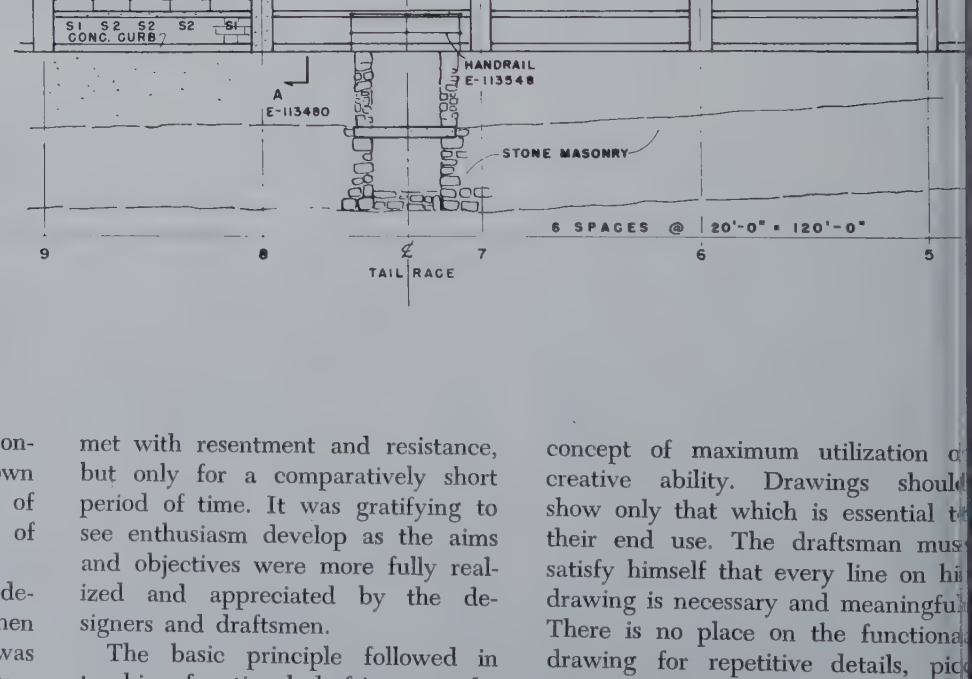


Fig. 2
AFTER—The same elevation with the principles of functional drafting applied.

sized that all details essential to construction would be shown and shown clearly without any possibility of misinterpretation due to the use of functional drafting practices.

The task of indoctrinating the design and drafting personnel was then begun. Here the initial reaction was exactly as anticipated. The program met with resentment and resistance, but only for a comparatively short period of time. It was gratifying to see enthusiasm develop as the aims and objectives were more fully realized and appreciated by the designers and draftsmen.

The basic principle followed in teaching functional drafting was the concept of maximum utilization of creative ability. Drawings should show only that which is essential to their end use. The draftsman must satisfy himself that every line on his drawing is necessary and meaningful. There is no place on the functional drawing for repetitive details, pictorial elaboration, excessive cross

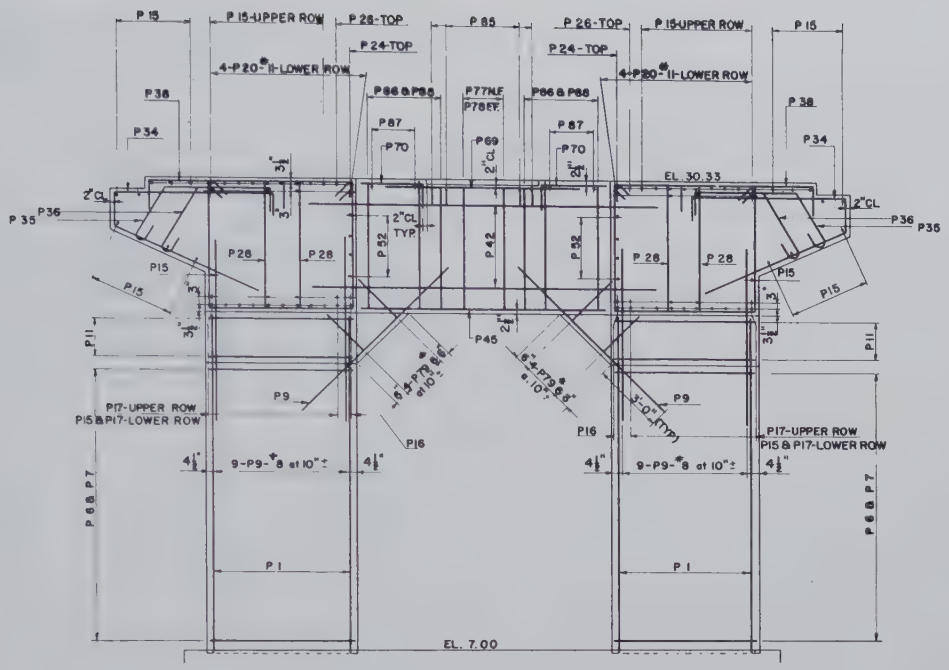


Fig. 3
BEFORE—An example of the old method of showing a turbine pedestal cross section.

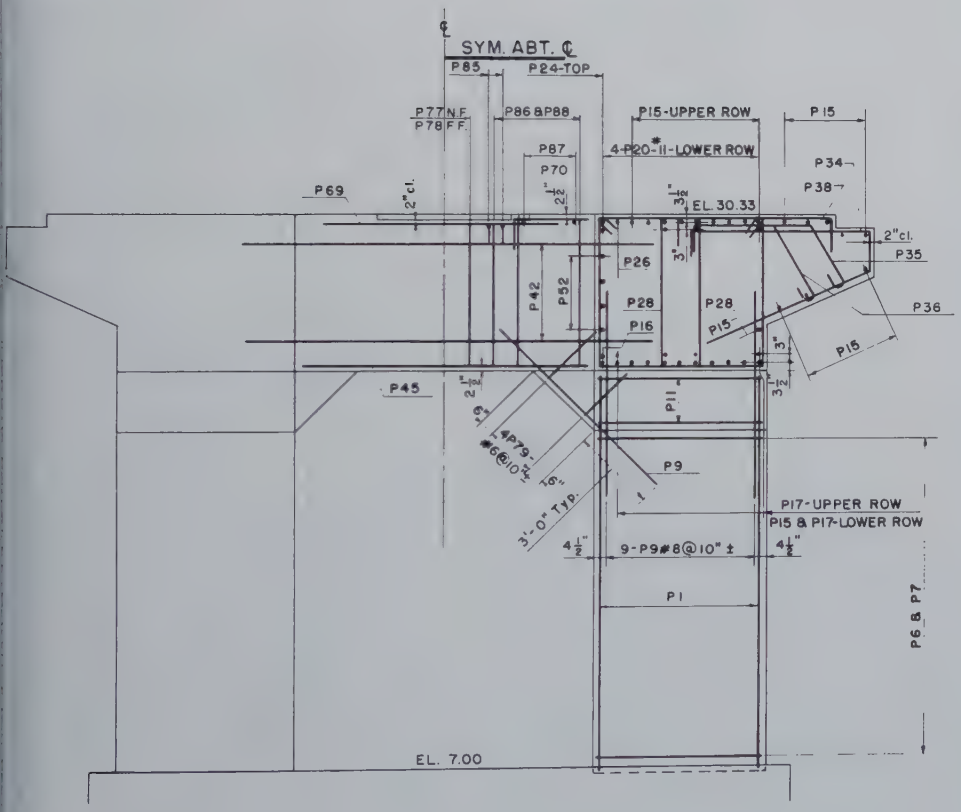


Fig. 4
AFTER—A functional drawing of the same pedestal using symmetry to eliminate unnecessary drafting and make it easier to read.

hatching and shading, superfluous sections and details, the full presentation of a view that is symmetrical about a center line, double lines to represent structural steel elements, piping, handrail, bolts and nuts.

It is virtually impossible to circumscribe with a given set of rules the specific limits within which a functional drafting operation can be performed. This is purely subjective and, although some samples can be illustrated, the operation rests mainly upon the thinking of the individual along the lines laid down previously.

Fig. 1 shows the exterior building elevation at the start of the functional drafting program. The masonry work is shown in detail with the duplication of typical items. Fig. 2 is the same elevation with the principles of functional drafting applied.

Figure 3 is an example of the old method of showing a turbine pedestal cross section. Fig. 4 is a functional drawing of the same pedestal using symmetry to eliminate unnecessary

drafting and make it easier to read.

Of course, as in all new undertakings, discretion must be used in the application of functional drafting restrictions. As an example, though shading, cross-hatching, and symbolic material designations are normally not used on the functional drawing, they may be used sparingly in a complicated detail to outline the component elements more clearly.

Standardization

The development and publication of a good set of design and drafting standards, or design guides as they are called at Ebasco, were essential to the new program. The use of the term *guide* rather than *standard* was established to give some assurance to the engineering department that, subject to the approval of the chief engineer, changes and deviations from the published guide could be made if deemed necessary. Maintaining the design guides on a current basis is a continuing project since they are revised and amended and new ones are added as technical developments may dictate. With the publication and distribution of the design guide books and the application of the many drafting standards contained therein, the drawings took on a new and distinctive look that made them recognizable as a product of Ebasco. There also followed a substantial reduction in design and drafting costs due to the elimination of time-consuming research on details which, though they could have been satisfactorily repeated from job to job, were often changed.

Copies of the actual design-guide sheets of certain standard items are sometimes sent to the fabricator in place of the drawings that would ordinarily be required. On large, complicated jobs manufacturers formerly submitted wiring diagrams for approval which were carefully checked by Ebasco and coordinated with other manufacturers' diagrams. Checking these manufacturers' drawings in such detail was a major and expensive procedure. Control wiring diagrams, outside of the control board, are now prepared by Ebasco and sent to the manufacturers. It is their responsibility to follow these diagrams and only a brief review of their drawings is made when they are submitted for approval.

Allied Economies

Upon investigation, it was found that the standard size Ebasco drawing did not conform to standard width reproduction paper, resulting in unnecessary waste. This was promptly remedied by changing the standard drawing size to make it conform.

The extensive use of adhesive overlays (appliques) for details, title blocks, general notes, listing of reference drawings, etc., was made an essential part of the program. Many of these are reproductions of applicable design guides.

Among other aspects of the program, a new emphasis was put on work schedules in order to hold emergency overtime requirements to a minimum. Time consumed in locating needed drafting equipment was substantially reduced by furnishing all drafting rooms with modern materials of good quality.

Some Results Obtained

Functional drafting has thoroughly sold itself at Ebasco and yet it would be folly to say that all of the economies stem from using one line on a drawing in place of two or three. Of greater importance is the fact that functional drafting encourages an individual to think creatively and in so doing makes him a more vital part of the engineer-designer-draftsmen team rather than a mechanical cog in a wheel. The proof of the effectiveness of the program is the very substantial reduction in man-days per drawing that has been achieved. The establishment of a cost-conscious atmosphere in the design-drafting department has paid excellent dividends. Everyone is constantly on the alert to the possibility of finding a more economical way of doing a job without sacrificing accuracy or clarity.

Maximum use of established standards and simplification procedures must continue to be encouraged. It is a never-ending process and its results, from the cost standpoint, should never be accepted as optimum. There is always room for further improvement. If efforts along these lines are relaxed, there is a tendency to backslide and much that has been gained over a long period of time can be lost very rapidly.

Problems and Conclusions

Functional drafting as practiced in Ebasco today represents the result of years of experience with this method. Since individual judgment, as has been previously indicated, plays a tremendously important part in this operation, it was found necessary in some instances to restrain the draftsman from going to extremes. The drawing to be truly functional must convey information in clear, unmistakable terms. In response to criticism which was solicited at the outset of the program, revisions were made to the ground rules originally established.

There is still resistance in some quarters to its unqualified acceptance. Errors on drawings which may result in field interferences are immediately attributed, by this small minority, to functional drafting. However, with but rare exceptions, it has been found after careful investigation, that they bear no relation to the proper application of functional drafting principles and practices.

Professional pride in high-quality workmanship is not sacrificed in the practice of functional drafting. On the contrary, the modern draftsman is relieved of many of the tedious drafting conventions that were once saddled on his earlier counterpart. He is thus in a better position to apply creative thinking to the constructive elements of his drawing. He recognizes the drawing as a means of communication only and not as an end in itself. His true objective is the successfully completed structure and he knows how to convey the needed information on his drawing clearly, concisely, and accurately. His operation is truly functional.

The Authors

E. L. Seeland is superintendent of design and drafting and P. B. Davis is assistant superintendent of design and drafting, Ebasco Services Incorporated, Engineers and Constructors, New York.

Application of Graphics to Engineering Design Problems

Some challenging examples of how graphics are used in the practical solution of engineering problems

by P. G. Belitsos

CONTROL OF FREE STATE VARIATION

Part I Continued

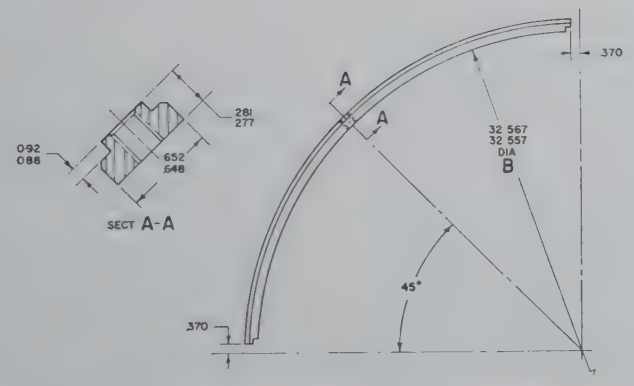


FIG. 7 COMPRESSOR VANE SPACER

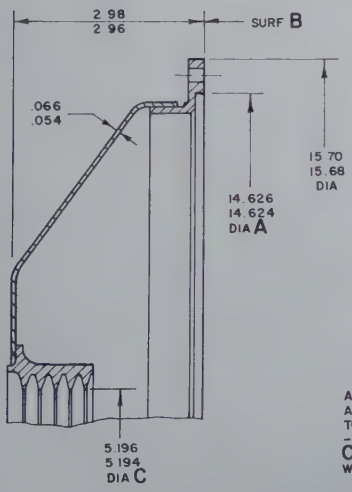


FIG. 8 COMPRESSOR OIL SEAL

LET US now look at the drawings of some parts which illustrate the use of datums and the control of the variation of surfaces which distort in the free state.

Compressor Vane Spacer (Fig. 7)

This is one quadrant of a simple part which is used as a spacer for the vane supports of a compressor. Since the part is relatively flexible when unrestrained, the drawing specifies that the spacer may vary from true shape in the free state. It also specifies that the important diameter B must be within drawing tolerance when restrained in a manner which simulates actual assembly conditions.

In this case the restraint consists of a single bolt applied at the center hole and at each end with the equivalent of 40 to 70 inch-pounds of torque.

Compressor Oil Seal (Fig. 8)

Here is another relatively simple application of the geometric control of nonrigid surfaces which distort in the free state.

The datum surfaces on this compressor oil seal consist of the locating diameter A and its related surface B. To simulate actual assembly conditions it is required that diameter A be mounted on a fixture which will restrain this diameter to within its specified diametral tolerance. The size of the mating rabbet diameter on the fixture is established on the basis of a close assembly fit with datum diameter A when it is at its maximum material condition which in this case is 14.624 inches. Surface B is then held flat by at least eight bolts

This paper was presented at the Summer Conference on Graphics in Scientific Engineering held at the University of Detroit, July 18, 1960 by the National Science Foundation.

placed through the clearance holes and fastened to the fixture with a torque of 50 to 70 inch-pounds.

In order to have an effective seal, it is necessary that the inside diameter of the teeth marked C be constructed around the datum axis within .004 FIR. This surface runout requirement establishes a tolerance zone which controls the combined errors of eccentricity, out of roundness and taper which may exist in the seal diameter. In addition, this tolerance zone also controls the squareness relationship of diameter C with datum surface B. These geometric form relationships must be met when the assembly is restrained as specified in the note.

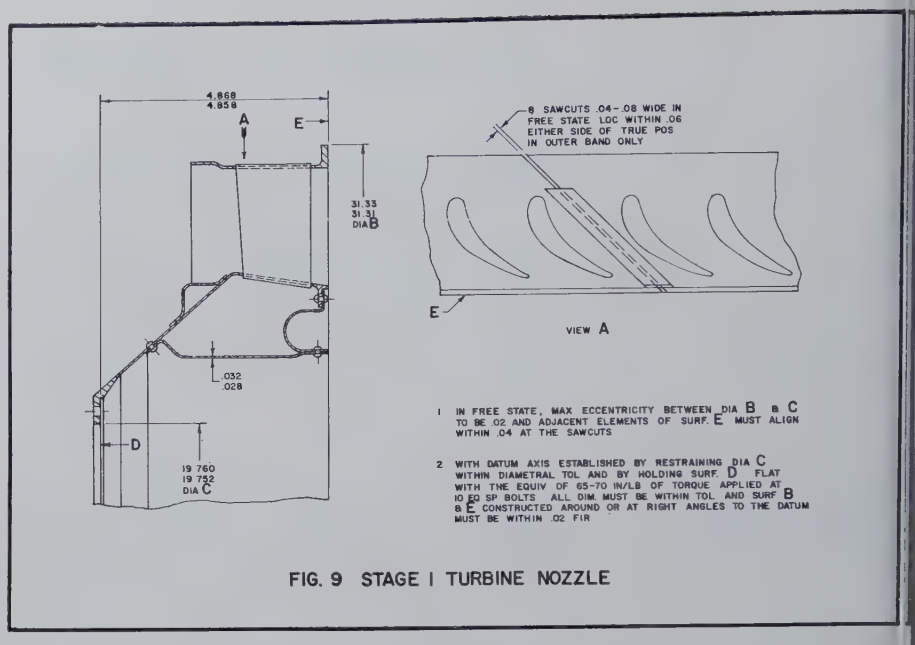


FIG. 9 STAGE I TURBINE NOZZLE

Stage 1 Turbine Nozzle (Fig. 9)

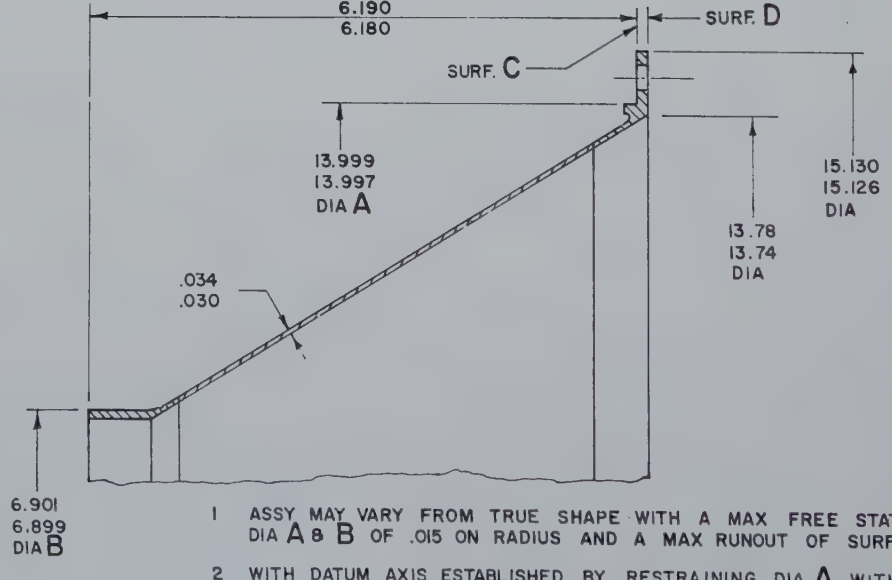
This permanently fastened assembly is one of the most difficult components of a turbojet engine to design and manufacture. The turbine vanes serve to direct the flow of the extremely hot gases when they leave the compressor on route to drive the turbine.

The datum surfaces consist of the locating diameter C and its related surface D. The drawing specifies that in the free state the maximum eccentricity between diameter B and C is to be within .02. It also specifies that in the free state the adjacent elements of surface E must align within .04 at the sawcuts. This controls the axial misalignment of surface E which is interrupted by the eight sawcuts.

To simulate actual assembly conditions, it is required that diameter C be mounted on a fixture which will restrain this diameter to within its specified tolerance. Surface D is then held flat by the equivalent of 10 equally spaced bolts which are torqued to 65 to 70 inch-pounds. With these surfaces establishing the datum axis the other related diameters and surfaces must meet the specified dimensional tolerances. In addition, diameter B and surface E which are respectively constructed around or at right angles to the datum axis must be within .02 FIR in the restrained position.

Turbine Shaft Air Seal (Fig. 10)

Here is a seal of a different design whose datum surfaces consist of thes

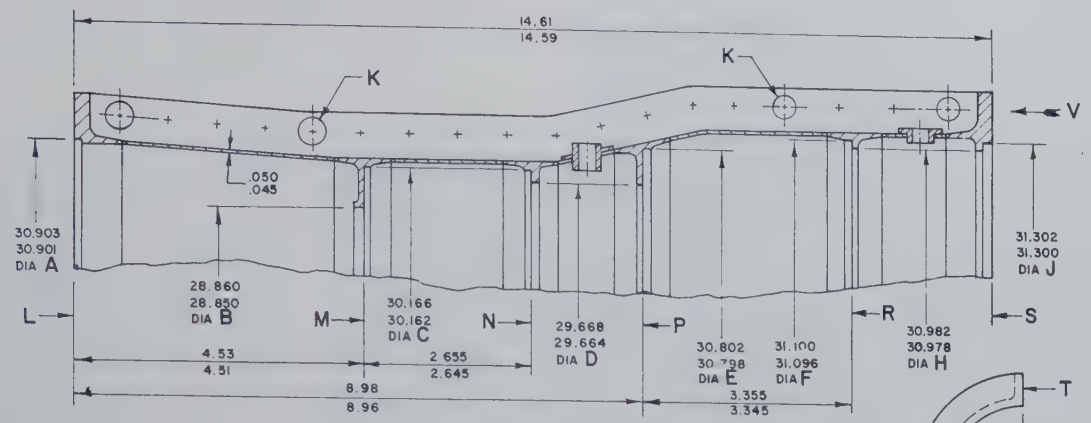


1 ASSY MAY VARY FROM TRUE SHAPE WITH A MAX FREE STATE OUT-OF-ROUNDNESS FOR DIA A & B OF .015 ON RADIUS AND A MAX RUNOUT OF SURF. C OF .010 FIR.

2 WITH DATUM AXIS ESTABLISHED BY RESTRAINING DIA A WITHIN DIAMETRAL TOL AND BY HOLDING SURF. C FLAT, SURF. B CONSTRUCTED AROUND THE DATUM AXIS MUST BE WITHIN .004 FIR. AND BE PARALLEL TO DATUM AXIS WITHIN .001

3 SURF. C & D MUST BE PARALLEL WITHIN .003

FIG. 10 TURBINE SHAFT AIR SEAL



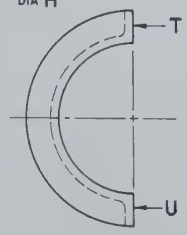
1 IN FREE STATE SURF. T & U MUST BE FLAT AND IN THE SAME PLANE WITHIN .010

2 IN FREE STATE WITH UPPER AND LOWER CASING HALVES BOLTED TOGETHER AT K, DIA A & J MUST BE ROUND WITHIN .02 ON RADIUS

3 WITH DATUM AXIS ESTABLISHED BY RESTRAINING DIA A & J WITHIN DIAMETRAL TOL AND BY HOLDING SURF. S FLAT WITH THE EQUIV OF 50 TO 70 IN/LBS OF TORQUE APPLIED AT 10 EQ SP BOLTS, THE SURF. CONSTRUCTED AROUND OR AT RIGHT ANGLES TO THE DATUM AXIS MUST BE WITHIN THE FIR. SPECIFIED IN TABLE I

SURF.	FIR.
B, C, D, E, F, H, L, M, N, P, R & S	.005
A	.002

TABLE I



VIEW IN DIRECTION OF ARROW V SHOWING CASING HALF
SCALE NONE

FIG. 11 TURBINE CASING ASSEMBLY

locating diameter A and its related surface C. The drawing in this case specifies that the locating diameter A and the seal diameter B may vary from true shape in the free state by being out of round to a maximum of .015 on radius. Also in the free state flange surface C may have an allowable runout of .010 FIR. If these allowable variations in the free state are exceeded the part is subject to rejection.

To simulate actual assembly conditions, it is required that diameter A be mounted on a fixture which will restrain this diameter to within its specified diametral tolerance. Surface C is then held flat and the seal diameter B must be within .004 FIR. In addition the drawing specifies that the elements of this cylindrical surface must be parallel to the datum axis with .001 which controls the taper of the surface and its squareness to datum surface C to a closer tolerance. The last note specifies the relative parallelism of the two faces of the flange.

Turbine Casing Assembly (Fig. 11)

Here is a very interesting application of free state variation control to a turbine casing assembly. The assembly is made up of two fabricated casing halves that are handled as a matched pair. The many close-toleranced diameters and locating flat surfaces which are shown in the cross section are machined while the casing halves are fastened together as an integral assembly.

You will notice that in the reduced scale view of the upper casing half taken in the direction of arrow V there is a requirement in Note 1 controlling the alignment of the flange surfaces T and U. The drawing specifies that these surfaces must be flat and in the same plane with .010 when the flanges are in the free state. In other words, the first engineering requirement is that these surfaces for each of the casing halves are inspected to the specified tolerance when they are removed from the fixture and are unrestrained.

The next engineering requirement covers the acceptable condition of the datum surfaces when they are unrestrained by external forces. The drawing specifies in Note 2 that when the two casing halves are bolted together at the 18 flange holes K, the datum diameters A and J must be round within .02 on radius in the free state.

The final engineering requirement establishes the expected geometric form and positional relationship of the functional diameters and surfaces when the structure is restrained in a manner equivalent to its actual assembly condition on the jet engine. To simulate this assembly condition the drawing in Note 3 identifies the datum axis established by surface S and diameters A and J. It specifies that surface S must be held flat with the equivalent of 50 to 70 inch-pounds of torque at a minimum of 10 equally spaced points on the flange. It also specifies that the datum diameters A and J must be restrained within their stated diametral tolerances. This establishes the equivalent of the assembly condition. The drawing then specifies that all of the diameters and flat surfaces identified in Table 1 must be within the full indicator reading which is specified as .005. It also establishes in Table 1 that datum diameter A must be within .002 full indicator reading.

This is an excellent example of how to control a series of surfaces of revolution whose circular elements are constructed around or at right angles to a common datum axis. This method will be further developed in reference to composite form tolerancing next month.

To Be Continued

New Products

Automatic Photocopier

A fully automatic photocopier that turns itself on, supplies the copy paper, makes exposure, peels away the negative, adjusts itself to any length original, trims, and delivers developed prints at the rate of four copies a minute is now being marketed by Ampto, Inc., Newton, N. J. Called Amptomatic, the unit makes black and white copies of all colors, will take any original up to 11" wide and of any length. Amptomatic is roll-fed, automatically cuts copies to the length of the original.

Paper Shredder

Destroyit No. 1 MM, a new model office paper shredder, destroys confidential records into the thinnest shreds possible with one push-button operation. Now available from Michael Lith Sales Corp., 145 West 45 St., N. Y. 36, N. Y., the machine has a movable cabinet and removable waste-bin for shreds. Simple enough for anyone to operate, the Destroyit provides 88 lbs. of shredded paper an hour, for packing and shipping material.

Multipurpose Copier

A new copying instrument called Rollacopier is now available, combining the features of microfilm reader, enlarger printer, wall projector, and contact printer. Stable prints of excellent sharpness can be obtained from this machine almost instantaneously and inexpensively. The Rollacopier comes in two sizes: Rollacopier 17 for prints up to 17" by 22" and Rollacopier 9 for prints up to 9" by 14". Information is available from Andrews Paper & Chemical Co., 676 Northern Blvd., P.O. Box 528, Great Neck, N. Y.

(For additional information regarding the new products described here, contact the manufacturer directly. Complete addresses are included.)

Low Cost Paper Plate Maker

A speedy, low-cost method for making paper plates for offset duplicating by using a Thermo-Fax copying machine has been announced by Minnesota Mining and Manufacturing Co., Dept. L1-162, 900 Bush Ave., St. Paul 6, Minn. Plates are made by a completely dry process, using the same technique as in copying any document. Total time involved is not over 30 seconds; cost per plate (ready for press) is as low as 12¢. The plate is durable, not affected by light, not sensitive to finger marks when handled. Because of the speed and economy inherent in this new method, the need to preserve and store plates for future use is eliminated, as in most cases it would be more economical to make new plates than preserve and store old ones.

Illustration Boards

Three new studio boards have been added to the Bainbridge line. Two of these are mounting boards with quality, bright white facing paper and grey backs. The third is a triple thick board with fine rag antique paper on one face and smooth illustration board paper on the other. Free samples of all three are available on request from Charles T. Bainbridge's Sons, 12 Cumberland St., Brooklyn 5, N. Y.

Quality Engraver

A high quality engraver has been added to the line of instruments for architects and draftsmen sold by Unitech Corp., 50 Colfax Ave., Clifton, N. J. Called Aristo, the new engraver can be used on all types of materials and coated surfaces. It has a built-in wide-angle lens with 4-time magnification, and is available with a variety of scribing points for single or double lines.

Fast-Printing Negative Paper

An improved version of their 408TG Photact contact photographic paper is now offered by Keuffel & Esser Co., Third and Adams Sts., Hoboken, N. J. The new paper has a faster emulsion which increases its printing speed without sacrificing photographic qualities. It is claimed to give clear, detailed negatives from tracings with weak lines, cracks, creases, or many fine lines. Corrections are made by etching, red-inking, or spotting.

High Intensity Vapor Lamp

A high intensity mercury vapor lamp of 200 watts per inch, for use in photo reproduction machines, is being introduced by Photo Print Equipment Dept., Hanovia Lamp Div., Englehard Hanovia, Inc., 100 Chestnut St., Newark 5, N. J. The lamps are available in 40-inch and 60-inch arc lengths, with wattages of 9,600 and 12,000, can be made in shorter arc lengths if there is sufficient demand.

Block Automatic Cutter

A completely automatic, labor saving machine for cutting strip processed rolls of paper is now being marketed by Alves Photo Service Inc., 14 Storrs Ave., Braintree 84 Mass. The electronic cutter accommodates paper up to 12" in width and in weights from 20 lbs. to 12 lbs. card stock. A spool receptacle holds rolls of paper 13" in diameter

The Book Shelf

ELECTRONIC DRAFTING HANDBOOK, by Nicholas M. Raskhodoff. The Macmillan Company, New York, 1961 ($14.75). Review by Irwin Wladaver.

THE SHEER MASS of material in *Electronic Drafting Handbook* is staggering. Mr. Raskhodoff has compiled a tremendous variety of useful information, detailed and well illustrated. The book gives clear evidence that its author is an experienced practitioner in electronics, as indeed he is. He obviously knows what kinds of authoritative data an electronics draftsman is constantly in need of. His book provides easy access to a comprehensive variety of items required in this newest branch of engineering drawing.

Every draftsman, beginner or experienced, who has a copy of the handbook will turn again and again to this reference treasure. Comparatively small it may appear, but it is remarkably comprehensive and usable. Mr. Raskhodoff shows how to prepare every kind of electronic drawing: schematics, wiring diagrams, working installation drawings of electronics and communication systems and equipment, tube-base diagrams, inter-connection and outline drawings. Finished sample drawings include a harness assembly, a primary power distribution program, a switching circuit schematic, a micro-wave circuit schematic, an audio system single line schematic, a production line wiring diagram, industrial control schematic and wiring diagrams, and many more.

A section crammed with photographs and figures introduces the beginner to the basic electronic and mechanical components. Typical drafting-room practices, techniques of drafting, and checking procedures for mechanical and circuit drawings are covered.

Let's look at the table of contents. Chapter 1 deals with "The New Profession of Electronic Drafting" and points out the expanding opportunities that abound in electronics, the young prodigy of industry. The next three chapters give "Basic Electronic Information." For example, Chapter 2 lists electronic components: capacitors, coils, connector varieties and numbering systems, and so on alphabetically for easy reference through wave guides and fittings, and wiring materials; plus a note on miniaturized electronic components.

Chapters 3 and 4 deal with mechanical components from bearings, bellows, and chassis through special aircraft fasteners; and materials from aluminum and its alloys through Teflon, a du Pont tetrafluoroethylene resin. Raskhodoff gives important information about Teflon's chemical, electric, and mechanical properties. Very interesting.

"General Electronic Drafting Techniques" is the subject of Chapters 5, 6, and 7. My personal prejudices make me wish that the author had given more space to drafting-room skills for the sake of green beginners, but of course such elementary stuff is readily available elsewhere. Most readers will, I think, find the chapter on general mechanical design quite useful and informative. It comprises among other items: early history, civilian *vs* military components, electronic entertainment equip-

ment, space planning, and chassis drawing details—there are too many to list them all.

"Special Electronic Drafting Techniques" is the subject of the next eight chapters. I have already intimated how great is the variety of topics touched on.

The last part of the handbook may well prove very useful to experienced electronics draftsmen. It is a 156-page encyclopedic reference appendix, jam-packed to include:

1. A digest of general specifications for military electronic equipment
2. A summary of the standard abbreviations of the Department of Defense and of the ASA
3. Tables of outline drawings and transistor types
4. A chart of tube-base diagrams
5. A summary of standard welding symbols
6. Tables of common electrical and electronic symbols
7. Tables of physical and mechanical properties of aluminum and of other metal alloys
8. Many more valuable charts and tables.

I felt that the $14.75 price for the handbook was rather on the high side and so I asked the editor to justify that much money for the book. He explained that one of the heaviest factors in the price was the tremendous number and array of linecuts, a very expensive process. Another factor was the fine quality of coated paper that makes the book more durable and at the same time keeps the volume comparatively thin. The linework is excellent, despite the fact that many illustrations are very small; and the half-tone reproductions are very good. And so the price of the handbook should be a minor matter to a person who can by means of the book increase his understanding, his knowledge, and his usefulness in his daily work.

Irwin Wladaver

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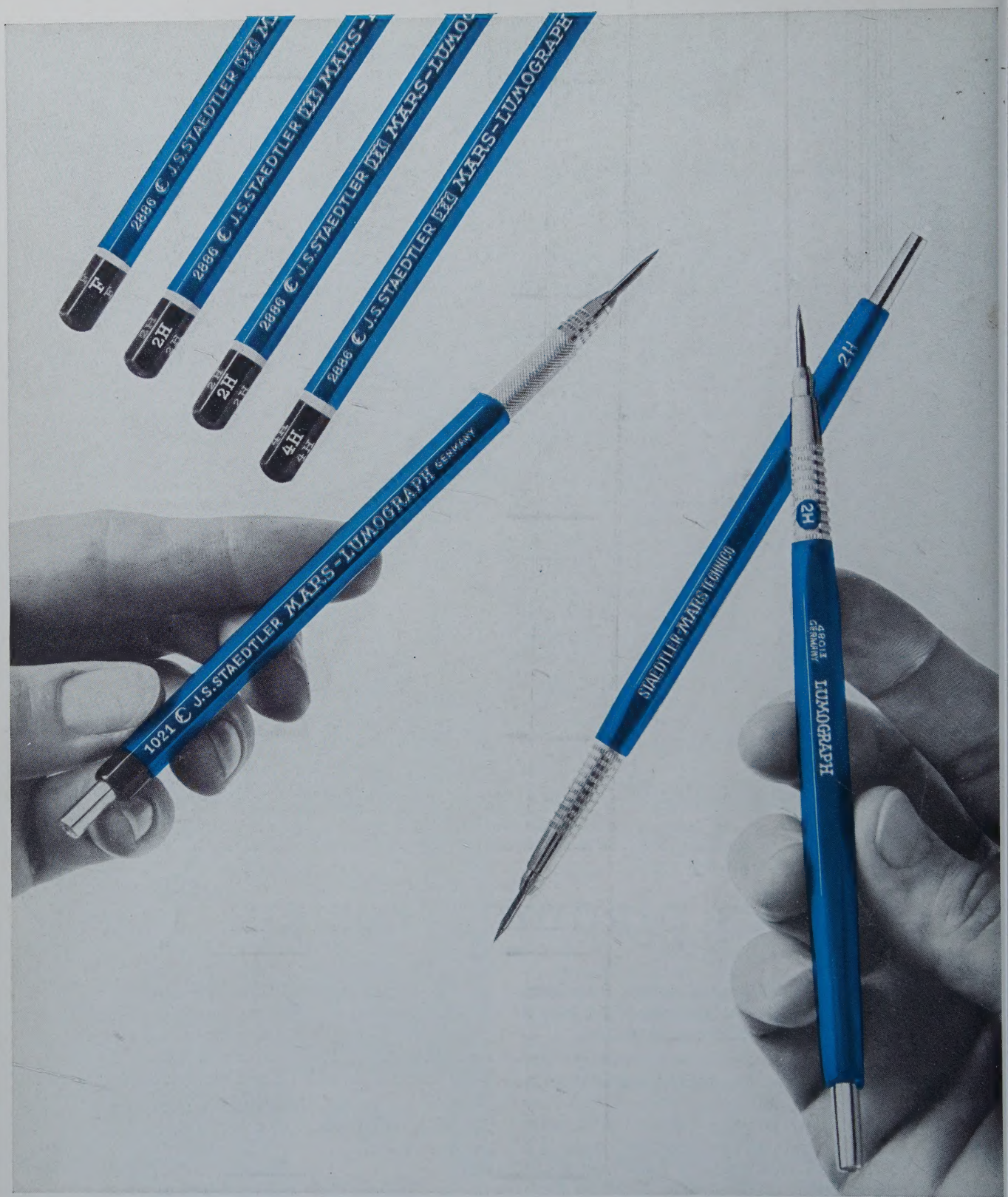

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